Telegraphy

By 1906. 70 years had already elapsed since the opening of the first operational telegraph circuit, and a major preoccupation was the transfer of the main overhead telegraph circuits to underground cables. Methods of operating the long-distance circuits included the Wheatstone, Murray, Baudot, Hughes and quadruplex Morse systems, and Wheatstone speeds of 400 words/min were commonplace. The development of the telegraph service is traced from that time to the present day, when the page-printing teleprinter has supplanted other instruments in the inland network and connexions are established via automatic telegraph exchanges. The growth of the telex service and the development of facsimile telegraphy are also described.

EARLY TELEGRAPH HISTORY

IN 1908, Sir John Gavey, the first President of the Institution of Post Office Electrical Engineers, wrote in his "Words of Welcome," to the first issue of the Journal:

> " . . . even as recently as 40 years ago, telegraphy was the only existing branch of electrical engineering, and when the present Institution of Electrical Engineers was founded in 1871, with the title of The Society of Telegraph Engineers, it fully represented the whole of our interests."

The idea of the "sympathetic needle" for communicating intelligence over great distances is very old indeed. It is fascinating to read[1,2] of the practical attempts that were made to establish alphabetic electric telegraphy (often using one wire per symbol), even before the work of Volta made possible a continuous source of electric power and so prepared the way for Oersted and Ampere to demonstrate the magnetic effect of the current.

Early in the 19th century, Cooke in this country produced improved instruments, using various numbers of line wires and magnetic needles from one to five, and in 1837 he collaborated with Wheatstone to provide the first operational telegraph circuit in the United Kingdom, for the railway between Euston and Camden Town. In the same year the electromagnetic relay was invented by Davy. Attempts to lay lines underground were unsuccessful because of poor insulation resistance, and for a long time development in this direction ceased in favour of overhead lines. In the public eye, interest was quickly awakened to the potentialities of the telegraph by the dramatic arrest of a murderer in 1845 as a result of a message sent over a circuit between Slough and Paddington. Single-needle and double-needle instruments in association with some form of code soon became established in this country, the double-needle being favoured by the railways, but with the gradual improvements in line insulation, constancy of battery performance, and instrument production, the sounder slowly superseded the single-needle instrument on Post Office circuits. The double-plate sounder, which enjoyed a long period of popularity until about 1880, consisted of a polarized relay and a pair of sounders, fitted with sounding plates of brass and steel, respectively, to denote dot and dash signals by different notes. Wheatstone's more expensive ABC instrument, which appeared in 1840, remained in use until long after 1900.

Apart from attempts at duplexing, two outstanding inventions between 1850 and 1875 were the printing system introduced by David Hughes, of Kentucky, in 1855, and Wheatstone's automatic system, which was patented in 1858, and when first brought into use in 1867 operated at 70 words/minute (w.p.m.) The Hughes system (Fig. 1) was an improvement on House's system of some seven years earlier; it used a piano-type keyboard and printed at 60 w.p.m. Hughes printers were in use longer than any other type-printing instrument, their supremacy declining only as the result of demand for greater speed; in fact, three such circuits were still in operation at the Central Telegraph Office (C.T.O.) up to 1939.

A time-division system had been proposed by Wheatstone in 1841, and successful experiments with such a system were carried out by Farmer ten years later. Meyer, in 1871, devised a four-channel system, using keyboards having eight keys and printing Morse characters on paper tape. Baudot combined a printing instrument with the multiplex principle and, most important of all, used a code with five units of equal length, and in 1877 the French Administration decided to adopt Baudot's system. A keyboard perforator (which punched square holes in paper tape) and a synchronous automatic tape transmitter were designed by Carpentier in 1887, but these instruments were not used in the telegraph services until much later.

Meanwhile, after taking over the private telegraph systems in the United Kingdom in 1870, the Post Office began to adopt duplex working extensively many years before it was used by other Administrations, although poor insulation resistance of lines and difficulty in obtaining accurately differential instruments presented a number of problems. Quadruplex circuits also came into use at this time (1872), and the first mobile telegraph office, complete with batteries and half a mile of three-wire iron-sheathed cable, was brought into service in 1873. In 1886, the American Delaney multiplex system appeared: despite many admirable devices such as the vibrating reed and phonic-wheel control, its use was abandoned in this country in 1903 after three years' trial, on account of the inherent mutilation of the signals. It used the Morse alphabet, fundamentally unsuited to multiplex systems, and was worked by key and sounder at 25 w.p.m.

The Post Office were slow in adopting the Hughes

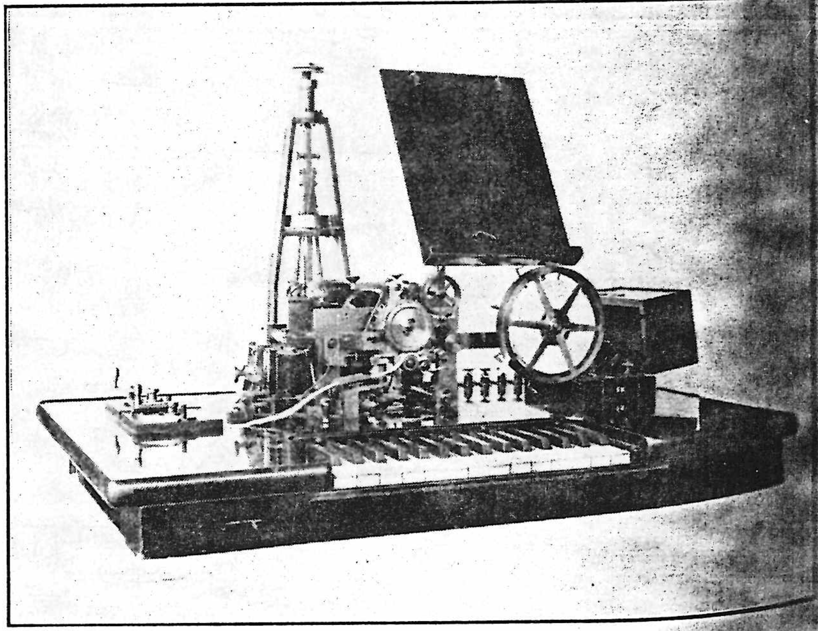


FIG. 1.—THE HUGHES INSTRUMENT.

The Post Office Electrical Engineers- Journal!
October 1956 vol 49 part 3

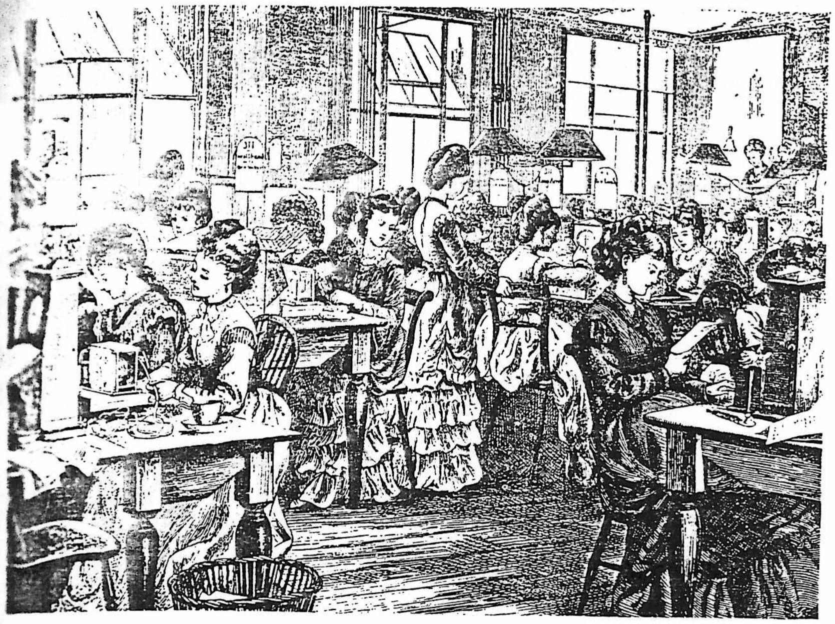


FIG. 2.—THE METROPOLITAN GALLERY, TELEGRAPH ST. (1871).

instrument because of its cost and the special training needed, although it was used widely on the Continent, but, with the acquisition of the Submarine Telegraph Company by the Post Office in 1889, the Hughes instrument came to be used extensively on Anglo-Continental circuits, the Post Office Factory making its own instruments from 1890, which used an electric motor in place of the original pedal-wound weight drive.

A 12-channel v.f. system was introduced by Mercadier in 1895 employing frequencies in the range 480 c/s to 900 c/s, tuned headgear receivers being used for reception, but this system caused interference with telephone circuits, and so did not progress beyond the trial stage.

In 1901 the Murray high-speed automatic type-printing system was introduced, only to be abandoned after more than ten years of trials on London–Edinburgh, London–Dublin and London–Berlin circuits. The equipment comprised a keyboard perforator (40 w.p.m.), automatic transmitter (120 w.p.m.), reperforator and column printer (100 w.p.m.), and incorporated such novel features as phonic-wheel drive and speed correction from the intelligence signals themselves; in the tape all perforations appeared longitudinally on one side only of the centre holes. Murray later focused the attention of telegraph engineers upon start-stop working and the five-unit alphabet.

It is interesting to note that in the early trials of keyboard perforators each perforator was associated with an automatic transmitter, which was automatically switched to the line, under the control of perforations inserted in the tape by the perforator operator after a given batch of messages. The line was shared by two automatic transmitters.

The Telegraph Scene Between 1906 and 1908

By 1906-1908, 70 years had elapsed since the opening of the first operational telegraph circuit, and the International Telegraph Union—the oldest intergovernmental organization—had passed its 40th anniversary. In February, 1908, at the annual dinner of the Engineering Department, the Engineer-in-Chief, Major O'Meara, claimed that the British telegraph service was acknowledged throughout the world to occupy the premier position. Competition from the telephone system had, however, already caused a considerable reduction in the number of messages circulating from one part of London to another.

A major preoccupation was the transfer of the main telegraph circuits to underground cables to afford greater security from storms, and the Northern and Western Underground telegraph cables were well on the way to completion.

The standard method of working inland circuits was by some form of duplex system using sounders: a side-stable polarized sounder had just been introduced which responded to double-current signals produced from a single-current battery at the central office, by the charge and discharge currents of a capacitor. The non-polarized sounder had had its day as a line instrument, because of its heavy power consumption, the troubles due to unskilled adjustment of the associated polarized relay, and the sounder-chattering caused by the response of this sensitive relay to voltages induced into underground circuits. At central offices where secondary cells were not available, groups of bichromate cells were installed.

At the C.T.O., which had been opened in 1871 and replaced Telegraph St. ("TS"), Moorgate (Fig. **2**) as the chief telegraph office of the Post Office, Metropolitan sounder circuits, as well as certain provincial circuits, were operated via new switching equipment (Fig. **3**). The equipment used lamp calling and clearing, and by saving nearly 4,000 transactions a day, reduced the average cross-London delay from 18 minutes to five. To accommodate some 150 short provincial omnibus lines, each serving two or more offices, a two position central-battery concentrator

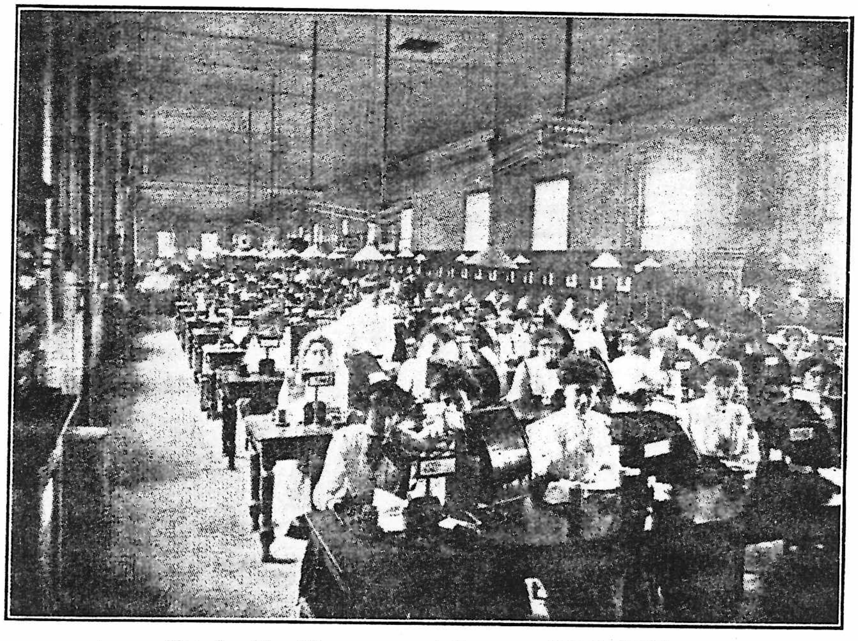


FIG. **3**.—THE METROPOLITAN GALLERY, C.T.O. (1911).

with lamp calling and clearing was installed in the C.T.O. Coincident with the new installations in the C.T.O., a task of considerable magnitude was completed—the conversion of all the London offices to central-battery (C.B.) working—and great economies were achieved from the abolition of well over 1,000 scattered groups of primary batteries.

Many miles of pneumatic tube had already been laid between branch and head offices; on the longest tube circuit, connecting the House of Commons to the C.T.O. (3,992 yd), the transit time was just under eight minutes.

Long-distance overhead circuits within the British Isles could be operated commercially by Wheatstone apparatus at speeds up to 300 w.p.m. duplex and 400 w.p.m. or more simplex; some quadruplex circuits were also in use. The Wheatstone system had changed very little since its introduction many years earlier. Trials were being made with electric-motor-driven transmitters, the main problem being the achievement of constant speed. Perforated tape was prepared by the three-punch "stick" perforator, but operation of this device for long periods was very tiring. To increase the speed of punching tape, trials were being made with early designs of alphabetic keyboard perforator, but they were not entirely successful. At the receiving end the process of transcribing messages from the Morse signals recorded by an inker upon a paper tape, often under artificial light, caused considerable eye-strain. As a result this system tended to fall into disuse.

Circuits to the European capitals were operated by printing telegraph systems, using the Hughes apparatus except for a single Baudot system to Paris. The Post Office operated five repeater stations, at Nevin, Llanfair and Haverfordwest on the Irish cables; at Lowestoft and N. Walsham on the Continental cables. Nevin, for example, had nine Wheatstone duplex and two quadruplex repeaters, the latter carrying Wheatstone and key signals. The Post Office standard B relay was firmly established. At repeater stations, sounders repeating all signals were the cause of great inconvenience, and silencers were being provided which could be rendered inoperative from the distant station when it was necessary to call the repeater staff. Repeater stations were being converted to secondary cell working, to replace the many groups of line and local batteries whose maintenance occupied the full time of one man.

At this time an investigation was being carried out into the speeds and relative economics of various methods of operating long-distance circuits, including Wheatstone, Murray, Baudot, Hughes and quadruplex Morse. Although the quadruplex system worked for many years on London–Dublin and other long circuits, with Wheatstone on the "A" (polarized) side and key at 25 w.p.m. on the "B" (incrementing) side, there was a tendency to split the keyed signals, and the repeater with its 12 relays and 15 separate batteries (368 bichromate cells) was troublesome to adjust; hence it cannot have been a very stable system.

In the large offices secondary batteries were installed to provide ±40V, ±80V and ±120V. The 80V and 120V sections were used only on the longer circuits and the loads at these voltages were lower than at 40V. A novel form of no-break rotary switch was therefore used to enable four sets of 40V cells to be cyclically switched, every two or three days as required, to occupy progressively different positions in the battery; each set in turn becoming available for charging, after which it carried the heaviest load (40V).

A Period of Transition (1908-1928)

From 1908 onwards the effect of the growth of the telephone service on the shorter-distance telegraph services became more pronounced. In the provinces, as well as in London, short-distance telegraph traffic decreased rapidly, and phonogram and telephone-telegram working were introduced. As fast as exchanges were installed in rural areas, Wheatstone ABC, Morse sounder and single-needle instruments, which had hitherto served small offices, were replaced by telephones used jointly for a public call office and as a means of disposing of telegrams, and by 1915 one-half of the 14,000 telegraph offices were operated by telephone. This process continued steadily until [illegible] when the last inland Morse circuit in the C.T.O. was closed quietly and without ceremony, and Morse working was only retained in the inland system for a few circuits.

This period saw the rationalization of power supplies in telegraph offices. In the first place, conversion to central-battery working obviated the need for large numbers of scattered groups of primary cells, and the standardization of an improved Leclanché cell in [illegible] led to the gradual abandonment of Daniell and bichromate cells. Secondly, as the spread of electric power mains brought charging facilities, conversions to secondary cells were steadily made, with considerable reduction in battery maintenance costs. Secondary cells in the C.T.O. replaced 5,000 "Z" cells used on underground loop circuits up to 1919; at the same time a ring-main was run to Fleet Street, so replacing 3,000 primary cells in newspaper offices by power supplies fed from the C.T.O. As secondary-cell batteries became universal the trend towards C.B. working was halted to obtain the improved transmission performance of double-current working.

During this period an extensive program of installing concentrator switchboards (including also some for phonograms) was completed at offices in all large towns. To dispense with the need for switchboard operators, this phase of evolution culminated in the installation of small automatic concentrators for trial at C.T.O. and Leicester (1923), and ancillary concentrators (for lines from "forwarding only" offices) which enabled the switching to be done by the receiving telegraphist. At this stage ([illegible]) the London Intercommunication Switchboard, which had been a conspicuous feature of the London telegraph system for over 20 years, was finally closed down.

The important changes of this period, however, were in the methods of long-distance operation, though they were in fact destined to revolutionize all forms of telegraph working. Development proceeded along three lines, automatic high-speed transmission, multiplex systems, and direct keyboard transmission. For a long time competition was between the first two, typified by the Wheatstone and Baudot system; the former, after initial success, yielded to the latter, but both finally gave way to the third.

Against the high transmission speed of the Wheatstone automatic system must be set the disadvantages of operating methods which, being slow, needed a team of sending and receiving telegraphists to feed the line and handle the output. Indeed, these very disadvantages had, over a long period of years, brought about a tendency to revert to key and sounder except for special arrangements, breakdowns and press work. To speed up the rate of tape perforation, trials had been carried out for many years with keyboard perforators whose punches derived their power from a pneumatic source, from electromagnets or from an electric motor: the successful keyboard perforator solved the Wheatstone sending problem. At the receiver, the dot and dash slip from the inker was transcribed—whether for delivery or for re-transmission—by one or more operators, and delays were frequent. A revised operating procedure, known as "Systematic Wheatstone Working"[3] was introduced in 1908, in which all Morse slip was gummed on message forms, that for delivery being transcribed direct, using typewriters, and through messages being re-transmitted without transcription, so reducing the error-rate as well as the delay. Such was the improvement that at Edinburgh, for example, it enabled four out of

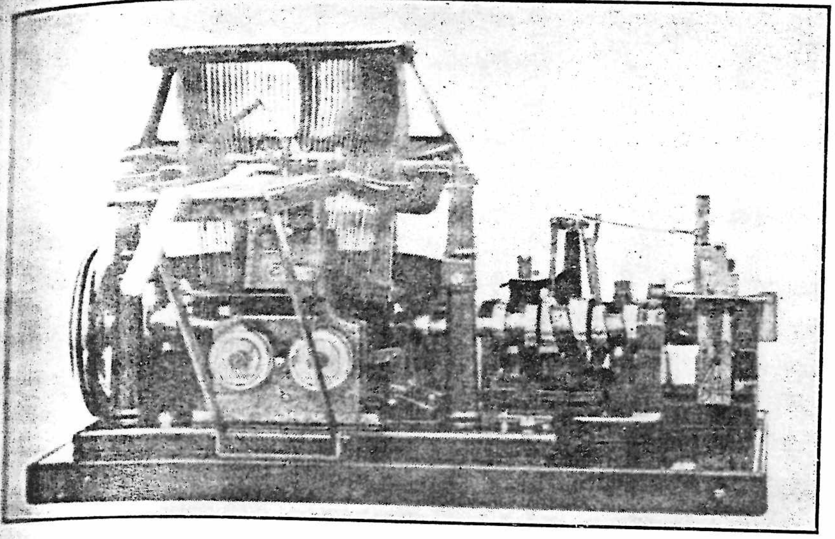


FIG. 4.—EARLY CREED PRINTER.

six London–Edinburgh circuits to be closed down, as well as the direct London–Inverness and London–Leith circuits. In London this procedure could not be carried out owing to the size and dispersion of the instrument room, but trials were in hand with a Creed reperforator and a Creed printer (Fig. 4); the reperforator automatically reproduced a perforated tape, at 150 w.p.m., which could be used direct for re-transmitting telegrams, or fed into the printer for producing a tape printed in Roman characters at 100 w.p.m., ready for gumming up. The subsequent improvement and adoption of keyboard perforators, reperforators and printers together with the provision of automatic transmitters, all electrically driven, put the Wheatstone automatic system on a firm basis in a form which is still in use for some radio circuits.

In Britain, multiplex systems were not looked upon with favour, largely due to the unsatisfactory results of the trials of the Delaney system and to some reluctance to embark upon large-scale adoption of any one system while other promising systems were under trial. True, a London–Paris Baudot system, working two channels simplex, had been operating satisfactorily since 1897, but in that form its output was no better than Morse-quadruplex and inferior to Wheatstone. In 1910, quadruple-duplex equipment was available for trials on a loop circuit in the London–Birmingham cable, and double-duplex trials were also made on a London–Berlin circuit. The French had long abandoned their only attempt to duplex the Baudot, on a Paris–Nantes single-channel circuit in 1887, on account of balance troubles coupled with the lack of any real justification for duplex working on that particular route. The protagonist of the Baudot duplex system,[4] against those who doubted its practicability, was A. C. Booth of the Post Office Engineering Department, and it was largely due to his efforts that the duplex Baudot was adopted, not only for the inland service, but also to displace the slower Hughes system on many Anglo-Continental circuits. Indeed, the British Post Office supplied apparatus and engineers to some of the foreign capitals to collaborate in setting-up Baudot circuits, and later supplied duplex repeaters to the French Administration for use on the London–Paris triple-duplex circuits. A lot of work was done to determine the relative efficiency of double, triple, quadruple, quintuple or sextuple Baudot, simplex or duplex, on any particular circuit whose Wheatstone speed was known. At 30 w.p.m./channel, the sextuple duplex was capable of maintaining 180 w.p.m. in two directions and provided formidable competition with the Wheatstone system at its best. As the result of consistently good performance the Baudot duplex system became firmly established technically in this country, so much so that in January 1914 the Postmaster-General appointed a Committee to inquire into high-speed telegraph systems. Telegraph engineers were rapidly coming to the opinion that the most promising line of telegraph progress was in type-printing multiplex systems.

A disadvantage of the Baudot system (Fig. 5) was the method of sending, which required the operator to memorize the 5-unit code in order to manipulate the five piano-type keys and to keep in exact cadence with the distributor. In the Murray and Western Electric multiplex systems, which the Post Office put on trial, the sending process was simplified by the incorporation of keyboard perforators coupled with automatic transmitters; other innovations were the use of phonic motors controlled from vibrating reeds to drive the distributors at a speed of 40 w.p.m./channel, and the introduction of page printers.

With the First World War telegraph traffic increased—91 million messages were handled in the United Kingdom in 1915. As a consequence the number of Wheatstone and Baudot systems had increased appreciably by the time the report of the High-Speed Telegraph Committee[5] was published in January 1916. The main conclusions of this committee endorsed the definite superiority of multiplex systems over high-speed automatic transmission for inland

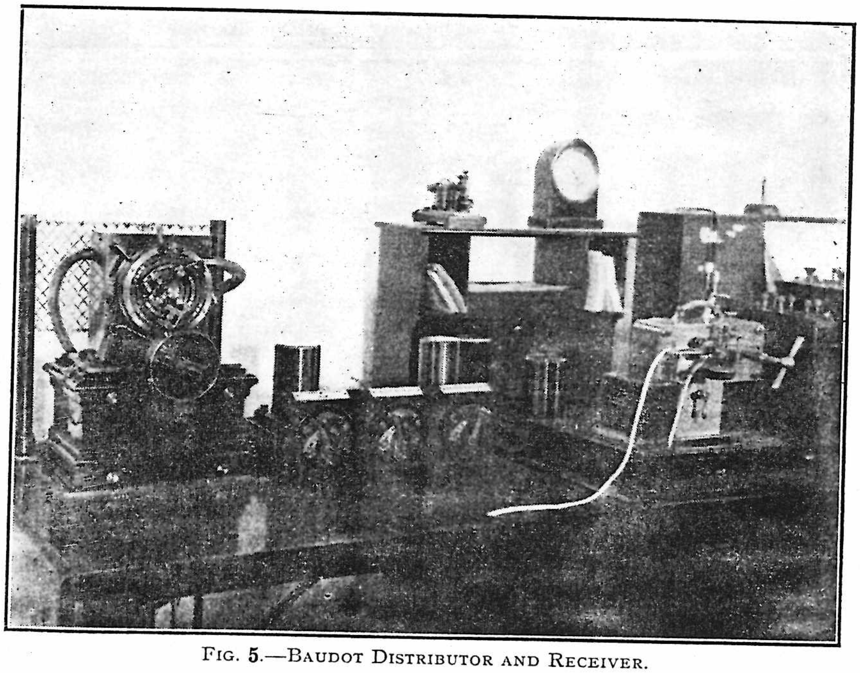


FIG. 5.—BAUDOT DISTRIBUTOR AND RECEIVER.

commercial traffic, and advised the gradual supersession of systematic Wheatstone by multiplex working. Other recommendations were that automatic transmitters be added to the Baudot equipment; that the 5-unit code was superior to Morse (excluding news traffic and submarine cable working); and that the application of printing telegraphy to less important circuits should be kept in mind. The committee also thought that page receivers were preferable to tape receivers.

After the committee's report, and particularly after the war, when apparatus was more easily obtainable, the use of duplex Baudot systems (mostly quadruple) extended rapidly both for the inland service, at the expense of Creed-Wheatstone and Hughes systems, and on Anglo-Continental circuits, where it superseded the Hughes system and doubled the output. The Baudot receiver was fitted with a mains-driven motor, the improvements already mentioned were incorporated in the later Baudot apparatus, and the speed was increased to 35 w.p.m./channel. By 1922 the number of Baudot channels had reached 700. The re-transmitter, a simple device which allowed channels to be coupled together and regenerated the signals, gave a certain amount of flexibility in utilization, though not without some complexity in connexion with speed control. This program of expansion was only halted by the decline in telegraph traffic which set in during the second half of the 'twenties. In all this program, and particularly on cable circuits, a most important part was played by the vibrating relay, invented by Gulstad in 1898, by means of which the performance and speed of operation of the circuits were appreciably improved.

In the early 1920s came the first of the radical changes to be made in telegraph technique and operation. In 1912 the first start-stop instrument had appeared in America, having been developed over a period of 12 years and more by Krum, a cold-storage engineer, financed by a Chicago millionaire named Morton. Far ahead of its time, this instrument used a typewriter keyboard in conjunction with a 5-unit code, and printed on a page. Some years later Morkrum instruments printing from a typewheel at 40 w.p.m., and known to the Post Office as the Teleprinter No. 1A, were giving satisfactory service in trials on two circuits in London. This was followed by other trials on longer circuits, and a Morkrum type-bar instrument working at 60 w.p.m. (Teleprinter No. 2A) was tried in 1925, one such instrument being used for booking calls over the new London–New York radio-telephone circuit. Other teleprinters[6] were also tried and by 1928 it was possible to standardize on the Creed No. 3A model with tape-printing at 65 w.p.m. for the inland service.

The general adoption in the early 1920s of loaded and repeatered underground cables for long-distance telephony raised fundamental problems in the transmission of telegraph signals through telephone cables. Investigations of d.c. transmission covered composited and superposed working; balanced circuits; and the design of new relays, such as the standard H relay, of increased sensitivity to work over long distances at reduced voltage and current. The solution to this problem of operating telegraph circuits in telephone cables clearly lay in voice-frequency telegraphy[7] and, following the development of filters, the first trials in this country were made in 1925 with Siemens-Halske 6-circuit v.f. telegraph equipment working over 40-lb loaded London–Derby and London–Manchester loops; then, in the following year, trials were made with a General Electric Company's 6-circuit v.f. equipment working over a London-Leeds, and later a London-Glasgow, circuit. In both equipments valves were used as oscillators (the G.E.C. equipment with tuning-fork control), amplifiers and detectors. The circuits used in the trial were equipped with Teleprinters No. 3A, of which several hundred were then in operation, some having already superseded Baudot apparatus.

For some time the need for standardization of alphabets and keyboards had been urgent. The Baudot system itself had variants for inland and international working, while the Murray system differed from both. The Baudot alphabet was designed primarily for ease in memorizing and manipulation on five keys, with the result that in keyboard working the numerals became scattered over the keyboard. The Murray alphabet was designed to take account of frequency of occurrence of letters in the English language, and so maintain the strength of perforated tape by punching the least number of holes in it; also, figures appeared in numerical order on a single row of keys.

The International Telegraph Union had never extended its activities far into the technical field, but in 1926 an organization was established to deal with technical matters: the International Consultative Telegraph Committee (C.C.I.T.). At its inaugural meeting in Berlin, in 1926, the C.C.I.T. decided to study the standardization of a single international 5-unit code based on the Baudot alphabet. A sub-committee was given the task of studying the problems of co-existence of telephone and telegraph circuits in the same cable. Until 1926 the only means of assessing the transmission efficiency of a circuit was in terms of the possible Wheatstone speed, or less precisely in its message-carrying capacity. At its first meeting the C.C.I.T. defined and recommended the baud as the unit of modulation rate to honour the memory of Emile Baudot. At its second reunion (1929), held also in Berlin, the C.C.I.T. recommended the adoption of two codes: the International Alphabet No. 1 for multiplex systems; and the International Alphabet No. 2 for start-stop systems. Both were basically Baudot codes but the latter had the secondary symbols re-arranged to suit keyboard layout, made provision for page teleprinters and included a change in the erasure signal to cover the use of perforated tape. This form of the Alphabet No. 2 was not, in fact, adopted; it was changed by a C.C.I.T. sub-committee, which met in Berlin in July, 1931, and was replaced by what was practically the Murray alphabet, differing extensively from the Baudot alphabet. The other more important recommendations of the 1929 reunion were a 50-baud standard for start-stop apparatus (the Creed No. 3A teleprinter worked at 49 bauds); the choice of negative polarity for the start signal and positive for the stop signal (this recommendation was not, however, adopted in this country, where the opposite conditions already prevailed); and the use of 7-unit start-stop receivers. The maximum permissible power (5 mW) for v.f. multi-circuit systems was also established and a sub-committee was appointed to study the question of frequency division for v.f. multi-channel systems.

THE TELEPRINTER AND V.F. ERA

With the introduction of the teleprinter and the development of a network of v.f. telegraph circuits, telegraphy changed its character completely.[8]

The v.f. network introduced complete flexibility as well as great economy in the provision and utilization of telegraph circuits, all with identical characteristics; it also removed the distinction between telegraph and telephone plant so far as cables and transmission equipment were concerned.

The teleprinter provided direct working to line at an adequate speed, and with the introduction of the page model (No. 7) in 1932 a telegraph instrument was available which, from its essential similarity to a typewriter, could be put into ordinary commercial offices.

As a result of these changes the techniques of testing and maintenance, for the first time, acquired precision in measurement. At its Third Reunion (Berne, 1931) the C.C.I.T. began to make recommendations for the measurement of distortion and margin, in addition to standardizing he carrier frequencies for multi-circuit operation. In the me year a 12-circuit system to the new 120 c/s spacing as in operation between London and Dundee.[9] Apart om superseding the polarized sending relay by a static odulator which appreciably reduced distortion, the sign of this equipment was not changed until 1951 when new detector of improved performance was introduced d the physical design changed. It has not yet proved acticable to displace the polarized telegraph receive relay. In 1932 development in superposing had reached the ge where it was possible to offer by-product point-to-point teleprinter circuits—phantoms and double-phantoms on main cable routes at rates that were attractive to the nter and remunerative to the Post Office. An extensive vate-wire teleprinter service was built up on this basis, until circumstances forced abandonment of this method of providing teleprinter circuits, by which time the v.f. network had grown sufficiently to cater for the growing ivate-wire service.

For a long time telegraph engineers had advocated the introduction of a telegraph exchange service, but, in the absence of a universal telegraph instrument and sufficient atively inexpensive similar circuits, those systems that d been tried, such as the sounder intercommunication switch, the Wheatstone ABC exchange, and the telewriter exchange, catered only for local services. In 32 the Post Office was a pioneer in introducing a telex rvice which, with only a limited v.f. network and demand service, was based on the use of telephone exchanges and the telephone network; transmission was on a 300-c/s (later 00 c/s) carrier, and page teleprinters were used. A rintergram" service was introduced for the direct handling telegrams between business houses using the service and telegraph offices. In **1936** a limited service with the Continent was opened, using 1,500 c/s transmission.

In the public telegraph service the introduction of the e teleprinter (No. 3), in association with v.f. circuits for the greater distances, quickly became universal. Instrument rooms acquired a new appearance with the introduction of ble-tables and conveyor belts; the auxiliary apparatus ich had hitherto encumbered operating positions was moved and mounted on apparatus racks. In the new conditions it became possible to envisage an automatically itched telegraph system, thus directly attacking the -old problem of reducing the number of times that grams were re-transmitted. A Re-transmissions Committee set up to study the problem reported in favour of a national teleprinter automatic switching system. Switching ipment was designed and successful large-scale field ls were held, but plans for the introduction of a pilot stage of the network were suspended on the outbreak of the Second World War.

One result of the war was the decentralization of telegraph rating from zone to area centres, a step which involved increase in re-transmissions and in staff. To reduce this extra work, it was decided to introduce a switching system h manual switchboards at six zone centres, the first two ng brought into service early in 1944.[10] The completed gram required the use of more than 1,500 circuits at 134 multiple switchboard positions, some 75 per cent of the tal public traffic being handled in this way. Manually ched teleprinter networks were also set up for the vices,[11] for various Ministries, and for other important ers, with the result that the v.f. network expanded nsiderably.

Radio teleprinter circuits were also brought into use, ploying two-tone and frequency-diversity transmission.[12]

After the war the resumption of telex working with the Continent became urgent; it was at once decided that this vice should be on the basis of a network of exclusively graph circuits using standard v.f. multi-circuit working. Temporary switchboards, which were quickly built, enabled service with Holland to be re-opened early in **1947**; this was followed by considerable expansion until at the present time the international telex switchboard in the C.T.O. (Fig. **6**) has more than 70 positions giving access to practically every European country, as well as to the whole of the United States and to parts of Africa. It is notable that since 1948 connexions with European subscribers served by automatic telex networks have been established by direct dialling from the C.T.O. switchboards.

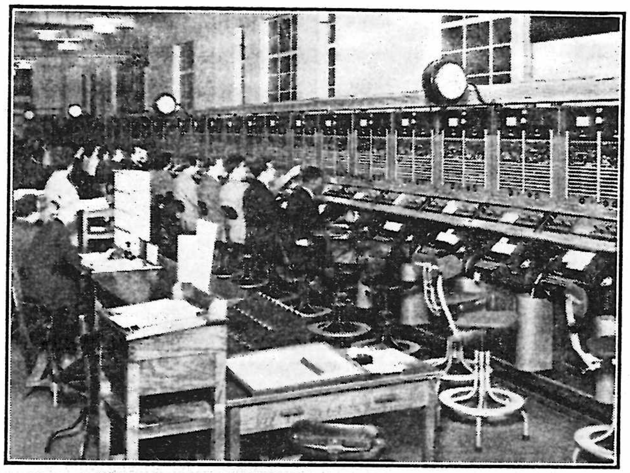


FIG. **6**.—THE INTERNATIONAL TELEX SWITCHBOARD, C.T.O.

For some time it had been apparent that operation of the inland telex service on the telephone network suffered from certain disadvantages, and a Committee set up in **1947** to study this question recommended the establishment of a new inland telex service using a network of exclusively telegraph circuits, to be started temporarily by using manually operated switchboards. The final stage in this conversion program was completed in 1954, giving complete flexibility between the inland and international telex services. At the present time there are just over 100 inland switchboard positions and approximately 3,000 subscribers.

The period of post-war activity included the conversion of the whole of the inland public network from manual to fully automatic working. The deferment of the pre-war switching scheme was not without advantage, since it gave the opportunity for further thought on signalling methods and resulted in the adoption of principles that were laid down for the telex service at the Sixth Reunion of the C.C.I.T. (Brussels, 1948). The conversion of the public service to automatic switching.[13] involving the opening of 22 telegraph exchanges serving 2,200 lines and the introduction of a new teleprinter (No. 11) conforming to international standards, was completed early in 1954 and has been very successful (Fig. **7**).

Concurrently with the adoption of the principle of random selection of v.f. circuits to form switched connexions, much work has been done in the design and utilization of electronic equipment for measuring and analysing distortion and investigating its cumulative effect in tandem-connected circuits.

FACSIMILE TELEGRAPHY

Facsimile telegraphy is almost as old as electrical telegraphy itself, having been introduced by Bain in 1842, using a receiver which recorded from five electrodes in contact with a moving tape of chemically treated paper, so reproducing letters that had been set up in metal type and scanned by five metallic feelers at the transmitter. The following year Bain patented an instrument in which scan-

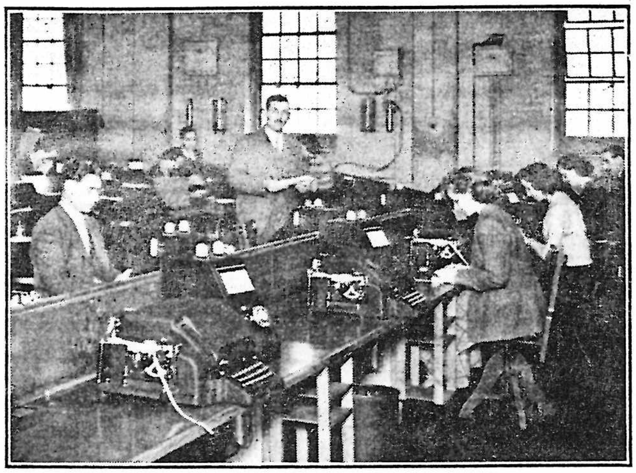


FIG. 7.—MODERN INSTRUMENT ROOM, EQUIPPED WITH TELEPRINTERS NO. 11.

ning and synchronizing were based on his electromagnetically-maintained pendulum; the swinging pendulum carried a scanning stylus and also controlled a traversing mechanism.

Bakewell, in 1848, patented a "copying telegraph" which laid the foundations for the design of orthodox present-day facsimile equipment. His instrument embodied a drum around which was wrapped the message form to be scanned, and an electrical contact device, traversing by means of a lead screw, scanned the message form. The message could be written in insulating varnish upon metal foil, or alternatively written upon a varnish-coated foil with a sharp point to expose the metal; recording, which could now include drawings, was again on chemically treated paper.

Various forms of non-facsimile chemical telegraphy were also in vogue for some years, and around 1910 the Siemens Photoprinter and similar machines used photographic paper for reception of printed characters: both these methods of telegraphy were capable of recording at speeds far in excess of existing electromagnetic means.

With improvements in electromagnetic telegraph instruments, facsimile telegraphy declined for some time until interest was revived following the development of photography. Some early work was carried out by Korn, who transmitted pictures by radio from Berlin to Paris in 1913. Ten years later a system was in use for transmitting pictures with limited tonal gradations by the use of ordinary five-unit perforated tape in conjunction with an automatic transmitter and reperforator: though special equipment was needed to prepare the tapes and record from it, the transmission itself was entirely by conventional telegraphic means.[14]

By the late 1920s the developments in photo-emissive cells, electronics, valve-maintained tuning forks and quartz crystals, and the availability of channels of suitable characteristics enabled picture transmission of reasonable quality to be realized. In 1928 the Post Office provided four-wire circuits into newspaper offices equipped with Bell or Belin photo-telegraph apparatus, and in the following year a public photo-telegraph service with Continental stations was opened with the installation in the C.T.O. of a Siemens-Karolus equipment.[15] At its Second Reunion (Berlin, 1929) the C.C.I.T. made recommendations for standardization of photo-telegraph apparatus and circuits.

The original picture-telegraph equipment was destroyed during the Second World War when the C.T.O. was very severely damaged, but in 1948 the service was re-opened using a new Muirhead equipment, and to-day the photo-telegraph service is world wide, using sub-carrier-frequency modulation for extra-European radio transmission.

TOWARDS THE FUTURE

It is difficult to foresee any radical changes in telegraph technique in the near future. From various causes, during recent years the inland traffic of the general telegraph service has fallen sharply. The future rests more with the telex service,[16] which is rapidly growing and has, no doubt, a remarkable development before it. Plans are well advanced for converting the inland telex service to automatic working within the next few years, and the ultimate aim is for [illegible] subscriber-to-subscriber dialling within Europe. A proposal is also being examined for the establishment of a European switched teleprinter-network for the general telegraph service.

The expansion of the international telex service has been aided by the recent introduction in this country of electronic regenerative repeaters, and of error-correcting equipment for use on radio circuits. To provide telegraph circuits over the transatlantic telephone cable, the first installation in this country of narrow-band frequency-modulated [illegible] telegraph equipment has been made.

Switching methods that involve the use of reperforators and automatic transmitters, interconnected automatically under the control of perforations forming the prefix in a tape, may, for special requirements, have advantages over more orthodox step-by-step systems. Equipment for this purpose has been developed and some systems of this type are already in operation. Magnetic storage methods may also have some influence on switching applications.

During recent years, trials have been in progress for the local transmission of telegrams by direct-recording facsimile telegraphy. It is difficult to foresee a wide application of this service, but the same technique is being applied in the reception of meteorological charts, and the C.C.I.T. is at the present time studying the question of design standards for such services.

References

[1] FAHIE, J. J. A History of Electric Telegraphy to the Year [illegible]. E. and F. Spon, 1884.

[2] ROBERTS, A. H. The Romance and History of the Electric Telegraph. *P.O.E.E.J.*, Vol. 16, pp. 121, 207 and 301, July, Oct. 1923 and Jan. 1924. Vol. 17, pp. 1, 91 and 171, Apr., July and Oct. 1924.

[3] MARTIN, J. Systematic Wheatstone Working. *P.O.E.E.J.*, Vol. [illegible], p. 322, Jan. 1911.

[4] BOOTH, A. C. The Baudot Printing Telegraph System. *I.P.O.E.E., Printed Paper No.* 9, 1907.

[5] Report of Committee Appointed to Consider the Question of High-Speed Telegraphy. *P.O.E.E.J.*, Vol. 10, p. 1, Apr. 1917.

[6] RITTER, E. S. Teleprinters. *I.P.O.E.E., Printed Paper No.* [illegible], 1933.

[7] CRUICKSHANK, W. Voice Frequency Telegraphs. *I.P.O.E.E. Printed Paper No.* 113, 1927.

[8] HARRIS, L. H., JOLLEY, E. H., and MORRELL, F. O. Recent Developments in Telegraph Transmission and their Applications to the British Telegraph Services. *Proceedings I.E.E.*, Vol. 80, p. [illegible], 1937.

[9] OWEN, J. M., and MARTIN, J. A. S. A Voice Frequency Multi-Channel Telegraph System. *P.O.E.E.J.*, Vol. 25, p. 8, Apr. [illegible].

[10] WILCOCKSON, H. E., and MITCHELL, C. W. A. The Introduction of Manual Switching of Teleprinter Circuits in the Public Telegraph Service. *P.O.E.E.J.*, Vol. 40, pp. 69 and 102, July and Oct. 1947.

[11] NANCARROW, F. E. The Telecommunications Network for Defence. *P.O.E.E.J.*, Vol. 38, p. 121, Jan. 1946.

[12] DAVIDSON, G. N., and PICKARD, R. J. A Multi-Channel Radio Telegraph Equipment. *P.O.E.E.J.*, Vol. 41, p. 148, Oct. 1948.

[13] WILCOCKSON, H. E., and MITCHELL, C. W. A. The Introduction of Automatic Switching to the Inland Teleprinter Network. *I.P.O.E.E., Printed Paper No.* 195, 1949.

[14] BOOTH, A. C. Picture Telegraphy. *P.O.E.E.J.*, Vol. 16, p. [illegible], Apr., 1923.

[15] RITTER, E. S. Picture Telegraphy. *I.P.O.E.E., Printed Paper No.* 129, 1929.

[16] RENTON, R. N. Telex Service. *I.P.O.E.E. Printed Paper No.* 207, 1956.

us line trouble when periodic
e ade for 180-degree correcti
re ions at all will be made to the
ency of the crystal oscillator.
Under these conditions Dingbat can
ch nism for 30 minutes. Actu
ch onger period can be tolerated
se it is also possible to hand
gb to correct for a speed drift
b beyond Dingbat's ability to
matically.

ngbat may also be used on direct
in olving no multiplex at all in
e-u Under this condition both
output speeds of Dingbat are the
no ift of the neon lamps should
ve The advance and retard
s are brought much closer toge
is type of operation. The input
or rushes are also started from
t f eplate to prevent a runaw
ion of the input distributor
ilure conditions. Thus a rece
ter with a single garbled rest
ot even produce one error where
andard start-stop operation such
gar ed pulse could result in a
ore characters.

bat equipments have been oper
communication circuits for
per ion experience indicates
ve provided a practical answer
lexing problem of establishing
ou communication circuit
es ecessary to superimpose
pon another independent
system.

---

t Steeneck, after graduating
hnology in 1926, joined the
taff of the Apparatus Engine
e Engineer of Automatics to
development of the newly
e. In addition to his accom
he was responsible for the
s line of Sport Timers; he assi
varioplex system and worked
Trainer project at the compa
n 1 4 he was transferred
ng eer's division to develop
office control for the Air
ent Mr. Steeneck is Assistant
nt ngineer and is engaged
s.

Western Union Technical Review
Jan '57
vol 11 no 1

GEORGE O. VINCENT, General PWS Supervisor, Facsimile and Private Wire Services

Self-Checking Codes for Data Transmission

Increasing use of telegraph facilities for transmission of business data in numerical form has generated studies of accuracy assurance. While, currently, all practical error detection systems involve redundancy, which reduces transmission speed or capacity, there are various pulse count methods and other means available for automatic error-checking.

In a recent press release about the installation of a "giant" electronic computer being placed in operation for the Signal Corps it was stated: "The computer collects and memorizes 8,000,000 different facts on more than 150,000 items required to keep the Army's global communication-electronics systems in operation. It uses these facts to process 6,000 orders for supplies received each day from troops throughout the world. It can make 30,000 logistical decisions per second and process [illegible]000 tabulating machine cards per minute."

Another announcement is about an electronic printer for use with such "brains" that is capable of translating and printing speeds up to 240,000 letters and numerals a minute. This produces in one minute 40 complete and different 8-1/2 by 11 inch business documents.

Such developments are occurring these days with increasing frequency and these two are mentioned here to point up the pressing requirement for speed and accuracy in telegraph transmission, with particular emphasis on private wire services. Communications facilities and equipment will be necessary to interconnect computer equipments for the rapid interchange of data in the growing use of more general and expanded applications of computers in the increasing pace of today's business. The greatest potential growth in private wire services is in the field of data handling to feed such "giants," and greater speeds will obviously be required if information is to be fed to such extensive data digestive capacities. It is the consensus in Western Union that a means of assuring accuracy in transmission is essential in this field and several ways of doing it are being devised and tested by our engineers. Western Union as the leader in the written communications field will be prepared to meet this need in integrated data processing.

Modern record communications facilities, particularly those utilizing frequency modulation, which Western Union pioneered for telegraph purposes, lend themselves readily to almost any practical signalling speed that may prove most advantageous from the standpoint of the computer and the work it must perform. Only relatively minor new developments in terminal equipment are required to accommodate a variety of speeds. However, speed of transmission is another subject.

As to accuracy, examples of our experiences in operating present facilities and equipment for data purposes may be of interest.

At Boston not long ago, IDP problems were introduced directly into an "Alwac" computer by Western Union teleprinter keyboard. There is nothing very startling about direct keyboard entry, but in this case the keyboard was in Boston on the Atlantic Coast and the computer, manufactured by Logistics Research, Inc., was located in Redondo Beach on the Pacific Coast, the two being connected by Western Union frequency-modulated carrier circuits. Mortgage computations, arithmetical problems, and trigonometric functions were being handled and the results printed in Boston within seconds of input. The same demonstration was repeated from Chicago. Combined, there was a total of six days of errorless transmission and computing.

Another experience was with an insurance company which in handling data by private wire service reported there were "only" (that is the customer's word) 32 errors in 25,000 punched cards which were converted from punched tape received by wire and not one of the errors was traced to our facilities but rather all were due to original punching.

Photograph R-10,526

Friden Add-Punch used in Western Union's payroll application

The Telegraph Company has been testing an internal payroll operation between the Baltimore office and New York headquarters. All phases are being carefully checked and analyzed. At Baltimore, on a Friden "Add-Punch" machine, the payroll data for each person are punched into 5-channel code paper tape as read from time cards. After the data for each person are perforated, the total of all the digits in the data for that person is recorded in the tape as a "nonsense" check total. The tape is then transmitted from Baltimore to New York. At New York the tape is run through a tape-to-card converter. Then the cards are run through a calculator and "zero balanced" to the "nonsense" total. If each card does not zero balance, an error is evident. Errors which did occur were directly traceable, the majority being due to operator error, and some few to the various pieces of equipment involved.

The occasional error in words is readily apparent, but in a string of random numbers it becomes more difficult to discern. If the cost of occasional errors to a particular type of business is not too great, and the cost of an error-detecting device is relatively high, it is more economical either to accept the errors or to provide a different means of detection. There are applications, similar to that mentioned in Western Union's handling of payroll, where summary totals will show whether errors have occurred, and it may thus be cheaper to ferret the occasional mistake rather than to pay for a seldom useful but continuously operating checking device.

It remains, however, that everyone concerned with IDP is interested in error checking. While there are several automatic checking methods, there is a balance to be struck between time loss from retransmission of the section of data containing an error and the time loss from tautology or signalling redundancy for error checking purposes. This means that if the error rate is relatively frequent, it would be advantageous to check frequently, in order to identify and the error as early as possible and save considerable retransmission time of whole sections of data.

The 5-channel or 5-level code used in both telegraph and private wire service consisting of various combinations of "marking" and "spacing" pulses not in itself provide a self-checking feature. A gain or loss of a pulse whether due to "hits" on the line or faulty equipment will result in an error. Incidentally, in referring to a 5-channel code, the start and stop pulses which cause it sometimes to be referred to as a "7-unit" or "7.42-unit" code are being disregarded.

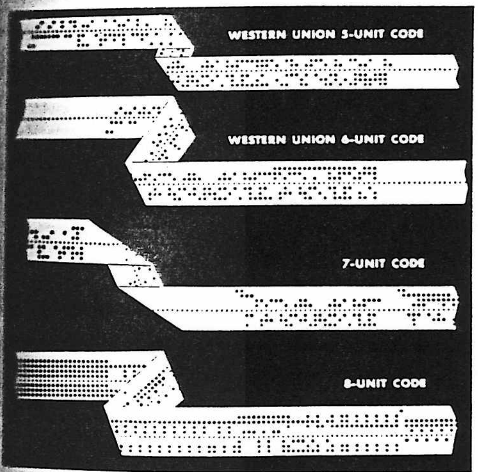
A 6-channel code is used for Teletypesetter operation to obtain more character assignments than are available with 5-channel code. Also the Commercial News Department of Western Union employs a 6-channel code for ticker service in the distribution of stock quotations. Here the object is to obtain the re

er ɔr error, and some fe
ieces of equipment invol
asional error in words is
bi in a string of rand
co es more difficult to
of occasional errors to a
of usiness is not too gr
of error-detecting de
high, it is more ec
ccept the errors or to p
ne s of detection. Th
s, milar to that menti
Union's handling of pa
um y totals will show wh
e curred, and it may
fe ret the occasional m
to pay for a seldom use
ly perating checking de
s, wever, that everyon
h IDP is interested in
Vhi e there are several
in nethods, there is a b
k tween time loss fr
of the section of da
rr and the time los
r gnalling redunda
ng purposes. This mea
rate is relatively freq
ad ntageous to chec
or r to identify an
early as possible a
ra retransmission t
s data.

nel or 5-level code
h and private wire s
of arious combin
a "spacing" puls
provide a self-check
r l s of a pulse wheth
he ine or faulty equ
an error. Incidental
5-channel code, th
s hich cause it som
e to as a "7-uni
de are being disregar
c e is used for Tele
n obtain more cha
ha are available w
e. Also the Comm
er of Western Unio
ne code for ticker
tion of stock quota
t i to obtain the requ

number of character assignments without the use of upper-case and lower-case shift functions. Neither of these applications provides for error detection by virtue of the code.

A sixth channel could be added to the standard 5-channel telegraph code and provide error detection by means of a parity check. However, this fails to satisfy the requirements for computer input for several reasons. In the first place, the code assignments of the digits in the standard telegraph code have no natural arithmetical progression for computer operation. Therefore, to avoid translation the code assignments must be changed. In the second place, the shift functions are as undesirable for computer operation as they are in telegraph ticker service. Thus computer designers have adopted 6-channel codes of their own to obtain code assignments of their own choosing without shift functions. A seventh channel is customarily added for parity checking.



Code tapes

The 7-channel code used with many computers provides 1-channel redundancy for an odd-even parity check. A 7-channel code is also used by RCA Communications for automatic error detection in telegraph transmission. In one application each character has three marking and four spacing pulses. If the received character fails to satisfy this ratio of marking and spacing pulses, the error is detected.

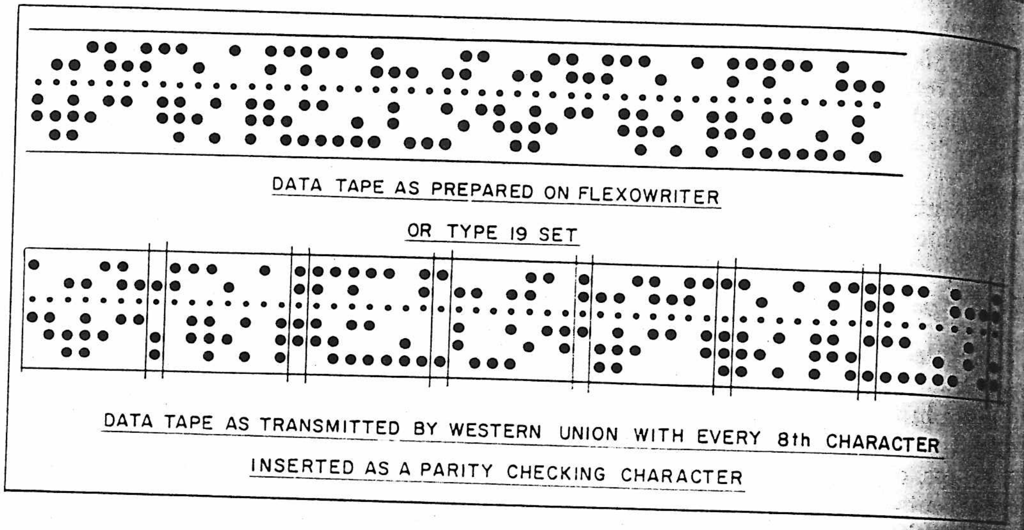
An 8-channel code, used with the IBM card transceiver, provides four marking and four spacing pulses per character. Errors in transmission are detected if a received character has more or less than four marking pulses. There are other variations of the 8-channel code used in some types of tape-to-card and card-to-tape converters.

The fixed mark-to-space ratio method of error detection is superior to the parity check for telegraph transmission. The distinction would be minor if the transmission errors were due to random effects. Analysis of actual transmission shows that the fixed ratio check will detect certain errored characters which will be passed by a parity check, while other compensating errors are undetectable by either method. While neither method is perfect it must be recognized that both the parity check and the fixed ratio check have considerable merit and that they are eminently satisfactory for many applications.

Where a higher degree of accuracy is required the character by character parity check may be supplemented by an odd-even check of the marking pulses in each channel of a group of characters. This is sometimes referred to as horizontal parity checking. There are several arrangements in which a horizontal check may be applied and unrestricted application of this principle will provide any degree of accuracy that may be required. There are practical and economic limitations, however, so it is necessary to establish the accuracy requirements of a particular service. Generally speaking, more redundancy results in higher accuracy. But more redundancy produces lower transmission efficiency and the equipment and circuitry are more expensive.

When operation is restricted to the 5-channel code one may examine the situation where the required number of characters is limited to the ten digits. There are exactly 10 code combinations having 2 marking pulses and 3 spacing pulses. Thus it is possible to apply a "2 out of 5" ratio check to this restricted application. If more than 10 but less than 16 combinations satisfy the requirements they may be derived from four of the channels and the fifth channel used for an odd-even parity check.

every 8th character. It could just as easily be every 10th, 12th or 80th character. It is most important, however, to recognize that the more characters transmitted between


DATA TAPE AS PREPARED ON FLEXOWRITER OR TYPE 19 SET

DATA TAPE AS TRANSMITTED BY WESTERN UNION WITH EVERY 8th CHARACTER INSERTED AS A PARITY CHECKING CHARACTER

Western Union's automatic 5-channel parity check

parity mark insertions, the greater the probability of experiencing a "compensating" error.

It is interesting to note the effect upon traffic volume with different check character spacings:

CHECK CHARACTER SPACING	PERCENT TRAFFIC INCREASE
8	14.3
10	11.1
12	9.1
80	1.3

For example, a sales order comprising [illegible] characters of intelligence would make [illegible] blocks of seven characters so the [illegible] number of characters transmitted to the line would be about 228 with every eighth character a check character. With 8-character spacing, the signals to be transmitted are increased by approximately 14 per cent.

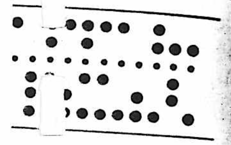
It is possible also to take a 6-level code, i.e., five levels and a parity check, and transmit it on 5-unit equipment and preserve the sixth level. For each group

The general case in which the required number of character assignments is 60 or less, any error detecting scheme for a 5-channel code must insert check characters at appropriate intervals.

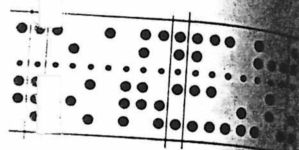
In one method the transmitted signals include a check character which is added to each block of signals by an insertion unit. The insertion unit counts the marking pulses horizontally by channels for, say, a block of seven characters, as illustrated. If the marking pulse count is odd in channel 1, for example, no marking pulse is added at channel 1 of the eighth character. If the marking count is even, as in channel 2, a marking pulse is inserted. Thus, every eighth character shown in the illustration is inserted as a "parity" check to make each block of eight characters show an odd number of marking pulses in each horizontal channel as transmitted to the circuit. A dropped or added pulse in any block obviously will change the arithmetic so that lack of parity will appear. This is considered a practical method of error checking and one which does not require excessive line transmission time.

The check character spacing need not be

haracter. It could just a
th. 12th or 80th charac
an however, to recog
aracters transmitted b



ER



EVERY 8th CHARACTER

TE

ieci

insertions, the great
experiencing a "compe

ting to note the effect
with different check

CTER	PERCENT TRA INCREASE
	14.3
	11.1
	9.1
	1.3

sales order comprising
tel gence would mak
n characters so the
acters transmitted t
ou 228 with every e
k aracter. With 8-
e signals to be transm
y approximately 14

lso o take a 6-level
nd a parity check
ur equipment and
ev . For each grou

five characters, the parity check "bit" is stored in memory equipment, and then the group of five parity bits is transmitted as the sixth character. Although not a startling development, it does illustrate a certain amount of compatibility between 5- and 6-unit code systems, when the sixth unit is for parity checking.

The 5-channel code has long been recognized as a standard in the communications field. At the same time, however, 6-, 7- and 8-unit codes are becoming increasingly popular which presents a problem of compatibility. IBM, Remington Rand, and others are working on methods of assuring accuracy in 5-unit transmission, and it is hoped that all will settle on a common method so that the transmission of 5-unit tape will be compatible in order to take complete advantage of the tremendous modern plant now operating on the 5-unit principle. The Telegraph Company is directing efforts toward this end, and also toward providing facilities and equipment for the transmission of 6-, 7- and 8-unit tape.

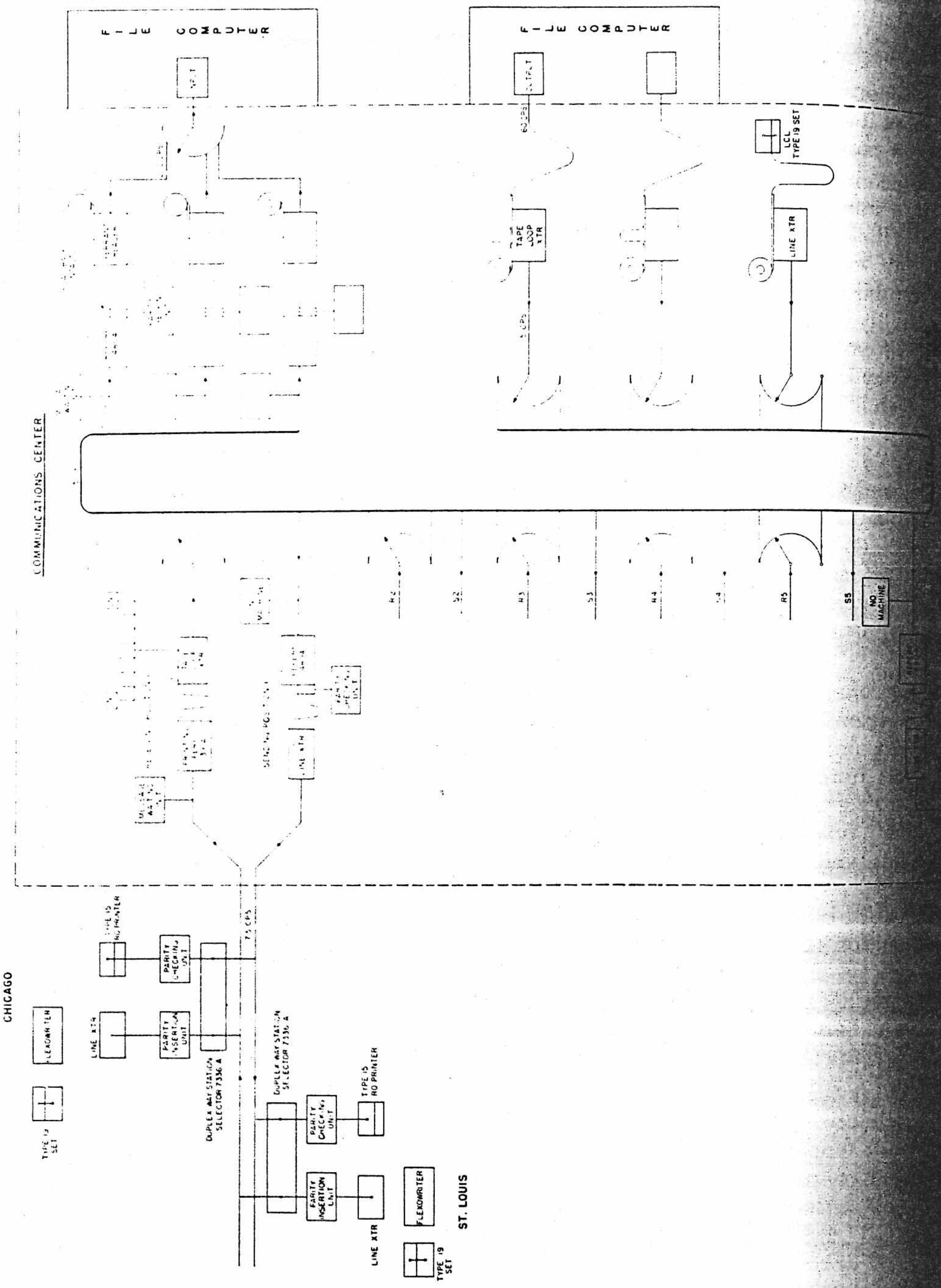
As mentioned before, many computers are working on the basis of 7-channel code, the sixth channel being added to provide additional functions, and the seventh channel being utilized for parity check. Work is in progress on multi-unit code equipment which will comprise a data communications network, and which ultimately will be capable of transmitting and terminating on magnetic tape for computer operations. At the same time, such a system would require teleprinters for intercepting data not required on magnetic tape. A system of this nature could provide transmission directly into a magnetic drum.

Extensive development work, resulting from market, equipment and system studies, is being done on another Western Union project entitled EDIT (Error Deletion by Iterative Transmission.) The EDIT system will be sufficiently flexible to accommodate 5-, 6-, 7- or 8-channel codes and will provide automatic error detection and *deletion*. Data will be prepared in blocks. Upon receipt of an errored character, the perforator will stop and at the end of the block the transmitter will be notified that an error has been received, and a "delete this block" symbol will be punched in the received tape after the errored character. The transmitter will reset the tape automatically and retransmit the group.

There is still the problem of 5-channel code with respect to the many applications and equipment which have been designed to utilize it. These applications simply cannot be converted overnight. Yet more accuracy is one of the objectives and necessities of IDP, and the standard 5-unit code as currently used does not provide a channel for obtaining a parity check. The use of a unit which can provide accurate 5-unit transmission without a parity checking channel was explored. Telegraph engineers developed a means of sending the signals for a character, followed by an inversion of the same signal, which are compared at the receiving end, and any

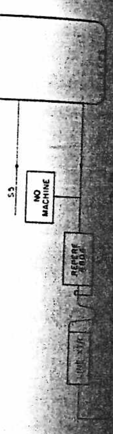
Photograph R-10,509

Type 28 teleprinter



Schematic of proposed communications network for file computer system with parity insertion and check

ured ch
was th
over
stem sin
gain or
reac
It may
uld be
ice and
s. How
named
n is aut
h rever
rors.
Another
lizes th
leprinter
annel a
stributor
eck cha
ck to th
CR LF
ed, lette
urn sig
cleared
mprehe
stunt h
hich cha
lse in it
state c
check
This po
availa



ity · sertion and check

errored character thus detected. This system was thought to have accuracy advantage over the single pulse parity check system since it eliminated the possibility of gain or loss of two pulses erroneously being read as a proper check.

It may appear that the same accuracy could be obtained by sending the data twice and comparing the two transmissions. However, the "5-by-5" system, as it was named, does more than this. Comparison is automatic, character by character, with reversal detecting possible line bias errors.

Another promising method of checking utilizes the "stunt box" of a Type 28 teleprinter. The marking pulses in each channel are "counted." A transmitter-distributor is used to read and send the check character to the circuit, and also back to the stunt box after a combination of CR LF LTRS (carriage return, line feed, letters shift) has been read. If the return signals are correct, the stunt box is cleared to check the next line. This comprehends a "flip-flop" arrangement in the stunt box for each channel in the code, which changes its state for each marking pulse in its channel. At the end of the line the state of the five "flip-flop's" determines the check character.

This possible check method uses 13 of the available 42 positions for function mechanisms within the stunt box. Ten are used for the check itself, one for marking and one for spacing for each of the five channels, and three for the CR LF LTRS sequence.

This method can be operated from either tape in the transmitter, or the keyboard, or both. Incoming material is checked by inserting a received tape in the transmitter and running it on a local circuit basis. If the odd-even count in the received tape for each line does not agree with the check character for the line in the tape, the equipment stops.

While some modifications may well be required in this method, it is probable that the stunt box mechanism in at least some applications will provide more accurate 5-channel code transmission systems and would be attractive to users.

These certainly are not the only means of providing more error-free received data, but were chosen to illustrate the point that data can be transmitted and received with a high degree of accuracy. Of course, the 5-channel code will convey more information than a 6-, 7- or 8-channel code in any time period if all bits are of the same length. All practical error-detection systems at present involve redundancy of some sort, and this redundancy is paid for by a reduction in speed or capacity.

Mr. Vincent's biography appeared in the October 1956 issue of TECHNICAL REVIEW

STANFORD UNIVERSITY
[redacted]
LIBRARY

DATA PROCESSING PACKAGE
FOR THE IBM 704

This manual describes the Data Processing Package for the IBM 704, which is intended to facilitate the coding of commercial programs.

The Data Processing Package was developed for the Applied Programming Department of IBM by the following staff members of the New York Data Processing Center, The Service Bureau Corporation:

S. Poley
F. T. Baker
M. Hanna
T. Arbuckle

The Data Processing Package program decks (symbolic or binary instruction cards) are available from:

704 Program Librarian
Applied Programming Publications
IBM Corporation
590 Madison Avenue
New York 22, N. Y.

© 1957 by International Business Machines Corporation

PART I: SUBROUTINE SPECIFICATIONS

INTRODUCTION

The Data Processing Package is an integrated set of subroutines which allow the 704 to operate on binary coded decimal (BCD) information. Input, output, information transfer and manipulation, and arithmetic are all performed on packed BCD data.

Flexibility is provided for interweaving binary 704 operations with BCD subroutine operations. Subroutines are provided to facilitate preparation of commercial reports. BCD arithmetic is performed in a 24-digit pseudo-accumulator.

The basic aim of the package is to reduce greatly the time and cost of initial programming of certain types of problems. Among these are:

1. Problems involving the reading and processing (with a modest amount of calculation) of successive input records and the writing of successive output records (file maintenance).
2. Problems involving considerable internal data manipulation.
3. Problems requiring an elaborate output format.
4. Problems involving mixed alphabetic and numerical input.
5. Problems of a one-time nature.

Use of the Data Processing Package does not require memory provision for the entire package. Only those subroutines actually to be used in an application need be in memory at any time. A simple scheme is available for loading these subroutines from a library tape at the time the program is run.

TERMINOLOGY AND SYMBOLS

The following terms and symbols are used to describe calling sequences:

Block = Group of sequential words.
A or B = Origin (first word) of a block.
W = Number of words in a block.

C = Origin of a control word table.
Field = Group of sequential characters imbedded in a block.
Numerical Field = Field whose units (rightmost) character is either a signed or unsigned digit and whose remaining characters are unsigned digits.
N = Number of characters in a field.
R, S = Position of the first (leftmost) character of a field.
T = Tape unit number (1-10).
t = Tag for indexing A, B, or C (t=0, 1 or 2).
W = Number of words in a block.

EXAMPLE

Assume that the first 72 columns of the card

Estimate No.	Job No.	Man No.	Date	Hours	Description
8039	01	363	07227	11.6	CLASSIFIED
1- -4	5- -6	7- -9	10- -14	15- -17	18- -72

are read into core storage as a 12-word packed BCD block (six characters per word) beginning at symbolic location INPUT. The block would appear in core storage as follows, letting b stand for a blank character:

803901	363072	27116C	LASSIF	IEDbbb	bb------b	bbbbbb
INPUT	+1	+2	+3	+4		+11

The following table indicates how each field of this card would be described in terms of the previously defined parameters:

A (or B) = INPUT

FIELD	N	R (or S)
Estimate No.	4	1
Job No.	2	5
Man No.	3	7
Date	5	10
Hours	3	15
Description	55	18

It is important to note that a field may be thus described without explicit information concerning the position of its individual characters within a block; i.e., we do not need to concern ourselves with the fact that the leftmost character of the HOURS field is the third character (counting from the left) of (INPUT +2). We need only realize that the HOURS field begins with the fifteenth character of the block starting at INPUT and is three characters in length.

To facilitate the processing of fields which are known to begin with the leftmost character of a word, omitting R or S in a field description will always have the same effect as setting R or S equal to 1.

GENERAL SPECIFICATIONS

Regardless of which subroutines are called into use, a section of the Data Processing Package known as the Universal Routine must always be present. The principal function of the Universal Routine is to supply a mechanism for reference to the various subroutines and to provide universal constants and erasable storage.

All of the subroutines in the Data Processing Package are entered by executing an instruction of the form TSX SUBR, 4 followed by an appropriate calling sequence, where SUBR stands for the beginning location of the subroutine.

The contents of index registers 1 and 2 prior to entry into a subroutine are always restored prior to exit from the subroutine. The contents of the MQ prior to entry into a subroutine remain the same upon exit from the subroutine in the case of BPB, ZAC, TZE, TNZ, TMI, TPL, TOV, TNO, and ALS. In all other cases the contents of the MQ are changed. The contents of the Accumulator are changed by all subroutines except ZAC.

READ CARD INTO PACKED BCD

Purpose

To read columns 1-72 of a decimal card, perform Hollerith to BCD conversion, and store the resulting packed BCD characters in a 12-word block of core storage, starting at A, t.

Calling Sequence

H	LOCATION	OP	ADDRESS TAG DECREMENT	COMMENTS
	α	TSX	RCD, 4	
	α + 1		A, t	
	α + 2			ERROR RETURN
	α + 3			EOF RETURN
	α + 4			NORMAL RETURN

Error Return

The presence of illegal Hollerith punching will result in an error return. Illegal punching does not terminate the conversion process and all legal columns will be properly converted. (See the appendix for legal Hollerith characters.)

Timing

To keep the card reader in motion, do not exceed 21 ms between the normal return and subsequent TSX to RCD.

Note

On an EOF return, the 12-word block starting at A, t will be cleared to zeros.

PUNCH PACKED BCD

Purpose

To convert to Hollerith a packed BCD block of W words beginning at A, t and punch a card. Punching will begin in column 1, assuming a SHARE punch control panel is used.

Calling Sequence

H	LOCATION	OP	ADDRESS TAG DECREMENT	COMMENTS
	α	TSX	WPU, 4	
	α + 1		A, t, W	W≤12
	α + 2			RETURN

Timing

To keep the card punch in motion, do not exceed 24.8 ms between the return and subsequent TSX to WPU.

PRINT PACKED BCD

Purpose

To convert to Hollerith a packed BCD block of W words beginning at A, t and print one line on the on-line printer. Printing will begin with the first (leftmost) type wheel, assuming a SHARE I or II printer control panel is used.

Calling Sequence

H	LOCATION	OP	ADDRESS, TAG, DECREMENT	COMMENTS
	α	TSX	WPR, 4	
	α + 1		A, t, W	W≤20
	α + 2			RETURN

Timing

To keep the printer in motion, do not exceed 114.7 ms between the return and subsequent TSX to WPR.

READ BCD TAPE

Purpose

To read one BCD record from tape T into a block of core storage beginning at A, t.

Calling Sequence

H	LOCATION	OP	ADDRESS, TAG, DECREMENT	COMMENTS
	α	TSX	RTD, 4	
	α + 1		A, t, T	T = 1, 2, ····, 10
	α + 2			ERROR RETURN
	α + 3			EOF RETURN
	α + 4			NORMAL RETURN

Error Return

An RTT check failure or false EOR or EOF skips result in an error return. In the case of false EOR or EOF skips, the accumulator is set to zero.

Usage

On either an RTT error return or a normal return, a word count is left in the decrement field of the accumulator. If the input record is not an exact multiple of six characters, the characters in the final incomplete word (< six characters) will be left in the low-order (rightmost) positions of the MQ.

Timing

(11.1 + .4W) ms per record. There is no "free" calculating time available between successive entries to RTD.

EXTRACT AND INSERT

Purpose

To move one or more fields from one block to another.

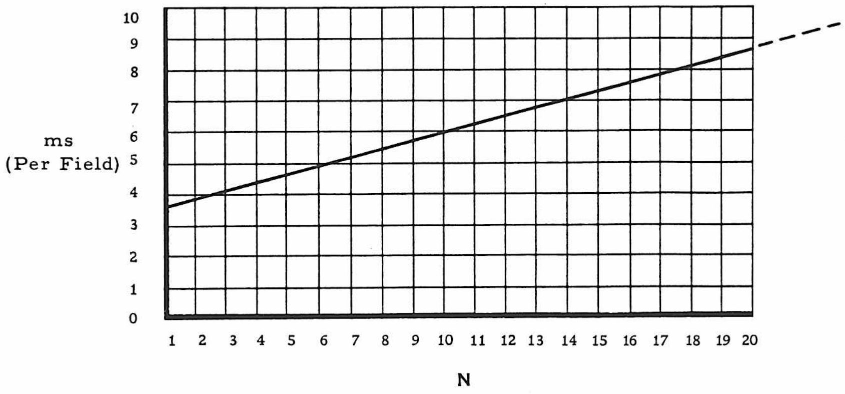
Calling Sequence (K = number of fields to be moved.)

LOCATION	OP	ADDRESS TAG DECREMENT	COMMENTS
α	TSX	XIN, 4	
$\alpha + 1$		N	N≦84
$\alpha + 2$		A, t, R	FROM
$\alpha + 3$		B, t, S	TO
$\alpha + 4$		N	
$\alpha + 5$		A, t, R	
$\alpha + 6$		B, t, S	
·		·	
·		·	
·		·	
·		·	
$\alpha + 3K - 2$		N	
$\alpha + 3K - 1$		A, t, R	
$\alpha + 3K$	MZE	B, t, S	
$\alpha + 3K + 1$			RETURN

Usage

Each group of three words in the calling sequence specifies a field to be moved. The calling sequence is terminated with a 1 in the sign bit of the third word of a group.

Timing



ALPHANUMERICAL COMPARISON

Purpose

To compare two fields.

Calling Sequence

LOCATION	OP	ADDRESS, TAG, DECREMENT	COMMENTS
α	TSX	COM, 4	
$\alpha + 1$		N	
$\alpha + 2$		A, t, R	FIELD 1
$\alpha + 3$		B, t, S	FIELD 2
$\alpha + 4$			ILLEGAL BCD RETURN
$\alpha + 5$			FIELD 1 > FIELD 2
$\alpha + 6$			FIELD 1 = FIELD 2
$\alpha + 7$			FIELD 1 < FIELD 2

Collating Sequence

$$\text{Blank} \cdot\ )\ +\ \$\ *\ -\ /\ ,\ (\ =\ \overset{+}{0}\ \ A \cdots I\ \overset{-}{0}\ \ J \cdots Z\ \ 0 \cdots 9$$

Restrictions

Control returns to ($\alpha + 4$) if either of corresponding unequal characters is illegal BCD. (See the appendix.) Corresponding equal characters are assumed to be legal BCD.

The COM subroutine cannot be used to compare signed numerical fields.

Since $\overset{+}{0} < (\overset{+}{1} \cdots \overset{+}{9}) < \overset{-}{0} < (\overset{-}{1} \cdots \overset{-}{9}) < 0 \cdots 9$,

the following results would occur:

$$1\overset{+}{5} < 1\overset{-}{5}$$

$$3\overset{+}{9} < 3\overset{-}{0}$$

$$2\overset{-}{1} < 2\overset{-}{4}$$

Signed numerical fields may be easily compared by means of either BCD arithmetic or conversion to binary.

```
                                       DPP1 DATA  PROCESSING PACKAGE                           DPP10000
                                                                                               DPP10001
                                                                                               DPP10002
                    00000          ORG 0                                                       DPP10003
                    00000          BSS 0                   UNIVERSAL COMPONENT                 DPP10004
                    00124    U     EQU 84                                                      DPP10005
                    00000    ()    EQU 0                                                       DPP10006
                                                                                               DPP10007
                                      UNIVERSAL CONSTANTS                                      DPP10008
                                                                                               DPP10009
00000  0 00000 0 00001   1A          1                                                         DPP10010
00001  0 00000 0 00010   8A          8                                                         DPP10011
00002  0 00000 0 00011   9A          9                                                         DPP10012
00003  0 00000 0 00012   10A         10                                                        DPP10013
00004  0 00000 0 00016   14A         14                                                        DPP10014
00005  0 00000 0 00100   64A         64                                                        DPP10015
00006 +000000000040      040A  OCT 40                                                          DPP10016
00007 +000000000051      051A  OCT 51                                                          DPP10017
00010 +000000000053      053A  OCT 53                                                          DPP10018
00011 +000000000054      054A  OCT 54                                                          DPP10019
00012 +000000000060      060A  OCT 60                                                          DPP10020
00013 +000000000067      067A  OCT 67                                                          DPP10021
00014 +000000000073      073A  OCT 73                                                          DPP10022
00015 +000000000077      077A  OCT 77                                                          DPP10023
00016  0 00001 0 00000   1D          0,0,1                                                     DPP10024
00017  0 00002 0 00000   2D          0,0,2                                                     DPP10025
00020  0 00014 0 00000   12D         0,0,12                                                    DPP10026
00021 +000077000000      CXSO  OCT 77000000                                                    DPP10027
00022  0 00000 1 00000   TAG1        0,1                                                       DPP10028
00023  0 00000 2 00000   2T          0,2                                                       DPP10029
00024  0 00000 7 00000   TAG7        0,7                                                       DPP10030
00025  0 77777 0 77777   CT          -1,0,-1                                                   DPP10031
00026  0 00000 0 77777   CTD         -1                                                        DPP10032
00027  0 00000 0 00447   LAC         AC                                                        DPP10033
00030  0 00000 0 00477   LAC24       AC+24                                                     DPP10034
00031  0 00000 0 00124   UA          U                      SIZE OF UNPACKED BLOCK             DPP10035
00032  0 00000 0 00052   HUA         U/2                                                       DPP10036
00033  0 00124 0 00000   UDEC        0,0,U                                                     DPP10037
00034  0 00052 0 00000   HUD         0,0,U/2                                                   DPP10038
00035  0 00000 0 00500   UDB         UD                                                        DPP10039
00036  0 00000 0 00477   UDM1        UD-1                                                      DPP10040
00037  0 00000 0 00552   UDPHU       UD+U/2                                                    DPP10041
                                                                                               DPP10042
                                     SHIFT TABLE                                               DPP10043
                                                                                               DPP10044
00040  0 00000 0 00000   ZERO        0                                                         DPP10045
00041  0 00000 0 00006   6A          6                                                         DPP10046
00042  0 00000 0 00014   12A         12                                                        DPP10047
00043  0 00000 0 00022               18                                                        DPP10048
00044  0 00000 0 00030               24                                                        DPP10049
00045  0 00000 0 00036   STAB        30                                                        DPP10050
                                                                                               DPP10051
                   00040   0000. SYN ZERO                                                      DPP10052
                   00000   0001. SYN 1A                                                        DPP10053
                   00041   0006. SYN 6A                                                        DPP10054
                   00001   0008. SYN 8A                                                        DPP10055
```

```
                   00002   0009. SYN 9A                                                        DPP10056
                   00003   0010. SYN 10A                                                       DPP10057
                   00042   0012. SYN 12A                                                       DPP10058
                   00044   0024. SYN STAB-1                                                    DPP10059
                   00035   LUD   SYN UDB                                                       DPP10060
                   00012   50B   SYN 060A                                                      DPP10061
                                                                                               DPP10062
00046 +000000000000            OCT                          77    ILLEGAL                      DPP10063
00047 +000000000000            OCT                          76    ILLEGAL                      DPP10064
00050 +000000000000            OCT                          75    ILLEGAL                      DPP10065
00051 -000011000000            OCT 400011000000             74    (                            DPP10066
00052 -000010000000            OCT 400010000000             73    ,                            DPP10067
00053 +000000000000            OCT                          72    ILLEGAL                      DPP10068
00054 -000046000000            OCT 400046000000             71    Z                            DPP10069
00055 -000045000000            OCT 400045000000             70    Y                            DPP10070
00056 -000044000000            OCT 400044000000             67    X                            DPP10071
00057 -000043000000            OCT 400043000000             66    W                            DPP10072
00060 -000042000000            OCT 400042000000             65    V                            DPP10073
00061 -000041000000            OCT 400041000000             64    U                            DPP10074
00062 -000040000000            OCT 400040000000             63    T                            DPP10075
00063 -000037000000            OCT 400037000000             62    S                            DPP10076
00064 -000007000000            OCT 400007000000             61    /                            DPP10077
00065 -000000606060            OCT 400000606060             60    BLANK                        DPP10078
00066 +000000000000            OCT                          57    ILLEGAL                      DPP10079
00067 +000000000000            OCT                          56    ILLEGAL                      DPP10080
00070 +000000000000            OCT                          55    ILLEGAL                      DPP10081
00071 -000005000000            OCT 400005000000             54    *                            DPP10082
00072 -000004000000            OCT 400004000000             53    $                            DPP10083
00073 -240025523200            OCT 640025523200             52    -0                           DPP10084
00074 -240036513111            OCT 640036513111             51    R    -9                      DPP10085
00075 -240035503010            OCT 640035503010             50    Q    -8                      DPP10086
00076 -240034472707            OCT 640034472707             47    P    -7                      DPP10087
00077 -240033462606            OCT 640033462606             46    O    -6                      DPP10088
00100 -240032452505            OCT 640032452505             45    N    -5                      DPP10089
00101 -240031442404            OCT 640031442404             44    M    -4                      DPP10090
00102 -240030432303            OCT 640030432303             43    L    -3                      DPP10091
00103 -240027422202            OCT 640027422202             42    K    -2                      DPP10092
00104 -240026412101            OCT 640026412101             41    J    -1                      DPP10093
00105 -000006000000            OCT 400006000000             40    -                            DPP10094
00106 +000000000000            OCT                          37    ILLEGAL                      DPP10095
00107 +000000000000            OCT                          36    ILLEGAL                      DPP10096
00110 +000000000000            OCT                          35    ILLEGAL                      DPP10097
00111 -000002000000            OCT 400002000000             34    )                            DPP10098
00112 -000001000000            OCT 400001000000             33    .                            DPP10099
00113 -200013523200            OCT 600013523200             32    +0                           DPP10100
00114 -200024513111            OCT 600024513111             31    I    +9                      DPP10101
00115 -200023503010            OCT 600023503010             30    H    +8                      DPP10102
00116 -200022472707            OCT 600022472707             27    G    +7                      DPP10103
00117 -200021462606            OCT 600021462606             26    F    +6                      DPP10104
00120 -200020452505            OCT 600020452505             25    E    +5                      DPP10105
00121 -200017442404            OCT 600017442404             24    D    +4                      DPP10106
00122 -200016432303            OCT 600016432303             23    C    +3                      DPP10107
00123 -200015422202            OCT 600015422202             22    B    +2                      DPP10108
00124 -200014412101            OCT 600014412101             21    A    +1                      DPP10109
00125 -000003000000            OCT 400003000000             20    +                            DPP10110
00126 +000000000000            OCT                          17    ILLEGAL                      DPP10111
```

```
00127 +000000000000          OCT                       16   ILLEGAL                        DPP10112
00130 +000000000000          OCT                       15   ILLEGAL                        DPP10113
00131 +000000000000          OCT                       14   ILLEGAL(-)                     DPP10114
00132 -000012000000          OCT 400012000000          13   =                              DPP10115
00133 +000000000000          OCT                       12   ILLEGAL                        DPP10116
00134 -300060513111          OCT 700060513111          11   9                              DPP10117
00135 -300057503010          OCT 700057503010          10   8                              DPP10118
00136 -300056472707          OCT 700056472707          07   7                              DPP10119
00137 -300055462606          OCT 700055462606          06   6                              DPP10120
00140 -300054452505          OCT 700054452505          05   5                              DPP10121
00141 -300053442404          OCT 700053442404          04   4                              DPP10122
00142 -300052432303          OCT 700052432303          03   3                              DPP10123
00143 -300051422202          OCT 700051422202          02   2                              DPP10124
00144 -300050412101          OCT 700050412101          01   1                              DPP10125
00145 -300047523200    BCD   OCT 700047523200          00    0                             DPP10126
                                                                                           DPP10127
                                UNIVERSAL SUB-SUBROUTINES                                  DPP10128
                                                                                           DPP10129
                                RESTORE AND RETURN ROUTINE                                 DPP10130
                                                                                           DPP10131
00146 -0 53400 1 00421   END    LXD XA,1               RESTORE                             DPP10132
00147 -0 53400 2 00422          LXD XB,2               AND                                 DPP10133
00150  0 02000 4 00000          TRA 0,4                RETURN                              DPP10134
                                                                                           DPP10135
                                                                                           DPP10136
                                INDEX ROUTINE                                              DPP10137
                                                                                           DPP10138
00151  0 60200 0 00435   INDEX SLW IND1                SAVE INPUT                          DPP10139
00152 -0 32000 0 00024          ANA TAG7                                                   DPP10140
00153  0 10000 0 00162          TZE IND2               IS TAG=0                            DPP10141
00154  0 40200 0 00022          SUB TAG1                                                   DPP10142
00155 -0 10000 0 00160          TNZ IND3               IS TAG=1                            DPP10143
00156  0 50200 0 00421          CLS XA                 TAG=1                               DPP10144
00157  0 02000 0 00161          TRA IND4                                                   DPP10145
00160  0 50200 0 00422   IND3   CLS XB                 TAG=2                               DPP10146
00161  0 77100 0 00022   IND4   ARS 18                                                     DPP10147
00162  0 40000 0 00435   IND2   ADD IND1                                                   DPP10148
00163 -0 32000 0 00025          ANA CT                 CLEAR TAG                           DPP10149
00164  0 02000 2 00001          TRA 1,2                                                    DPP10150
                                                                                           DPP10151
                                LOCATE FIELD START                                         DPP10152
                                                                                           DPP10153
00165 -0 63400 2 00436   LFS    SXD LFSB,2             SAVE IR-2                           DPP10154
00166  0 07400 2 00151          TSX INDEX,2            INDEX ORIGIN                        DPP10155
00167 -0 73400 2 00000          PDX 0,2                                                    DPP10156
00170  3 00000 2 00174D         TXH LFS1,2,0           IS DEC=0                            DPP10157
00171  0 53400 1 00041          LXA 6A,1               SET IR-1=6                          DPP10158
00172 -0 53400 2 00436          LXD LFSB,2                                                 DPP10159
00173  0 02000 2 00001          TRA 1,2                                                    DPP10160
00174  0 62100 0 00431   LFS1   STA LFSA               DEC. NOT ZERO                       DPP10161
00175  0 40200 0 00016          SUB 1D                 (DEC-1)                             DPP10162
00176  0 76500 0 00065          LRS 53                                                     DPP10163
00177  0 22000 0 00041          DVH 6A                 (DEC-1)/6=Q+REM                     DPP10164
00200  0 40200 0 00041          SUB 6A                                                     DPP10165
00201  0 73400 1 00000          PAX 0,1                SET IR-1=(6-REM)                    DPP10166
00202 -0 60000 0 00437          STQ LFSQ               SAVE Q                              DPP10167
```

```
00203 -0 50000 0 00431          CAL LFSA                                                   DPP10168
00204  0 36100 0 00437          ACL LFSQ                                                   DPP10169
00205 -0 53400 2 00436          LXD LFSB,2                                                 DPP10170
00206  0 02000 2 00001          TRA 1,2                                                    DPP10171
                                                                                           DPP10172
                                SET UP BLOCK ADDRESS                                       DPP10173
                                                                                           DPP10174
00207 -0 63400 2 00432   SBA    SXD SBAB,2                                                 DPP10175
00210  0 07400 2 00151          TSX INDEX,2            INDEX ORIGIN                        DPP10176
00211  0 62100 0 00432          STA SBAB                                                   DPP10177
00212  0 77100 0 00022          ARS 18                                                     DPP10178
00213  0 73400 1 00000          PAX 0,1                SET IR-1=W                          DPP10179
00214  0 36100 0 00432          ACL SBAB               (A+W)                               DPP10180
00215 -0 53400 2 00432          LXD SBAB,2                                                 DPP10181
00216  0 02000 2 00001          TRA 1,2                                                    DPP10182
                                                                                           DPP10183
                                EXTRACT FIELD TO UD                                        DPP10184
                                                                                           DPP10185
00217  0 53400 1 00000   XTR1   LXA 1A,1               SET IR-1=1                          DPP10186
00220 -0 63400 2 00440   XTR    SXD XTRB,2             SAVE IR-2,4                         DPP10187
00221 -0 63400 4 00441          SXD XTRX,4                                                 DPP10188
00222 -0 63400 1 00433          SXD XTRN,1             SAVE N                              DPP10189
00223  0 07400 2 00165          TSX LFS,2              LOCATE FIELD START                  DPP10190
00224 -0 63400 1 00443          SXD XTRR,1             SAVE (6-REM)                        DPP10191
00225  0 76000 0 00006          COM                                                        DPP10192
00226  0 60200 0 00442          SLW XTRC               SAVE 1COM(A+Q)                      DPP10193
00227  0 73400 2 00000          PAX 0,2                SET IR-2=1COM(A+Q)                  DPP10194
00230 -0 50000 0 00433          CAL XTRN                                                   DPP10195
00231  0 77100 0 00022          ARS 18                                                     DPP10196
00232  0 73400 4 00000          PAX 0,4                SET IR-4=N                          DPP10197
00233  0 36100 0 00035          ACL UDB                (UD+N)                              DPP10198
00234  0 62100 0 00243          STA XTRU                                                   DPP10199
00235 -0 50000 1 00046          CAL STAB+1,1           SET UP INITIAL SHIFT                DPP10200
00236  0 62100 0 00240          STA XTR2                                                   DPP10201
00237  0 56000 2 77777          LDQ -1,2               GET 1ST PACKED WORD                 DPP10202
00240 -0 77300 0 00000   XTR2   RQL ()                 AND SPIN TO 1ST CHAR.               DPP10203
00241  0 76000 0 00000   XTR4   CLM                                                        DPP10204
00242 -0 76300 0 00006          LGL 6                  UNPACK AND STORE                    DPP10205
00243  0 60200 4 00000   XTRU   SLW (),4               IN UD BLOCK                         DPP10206
00244 -2 00001 4 00251          TNX XTR3,4,1           TEST FOR N CHAR.                    DPP10207
00245  2 00001 1 00241          TIX XTR4,1,1           TEST FOR 6 CHAR.                    DPP10208
00246  0 53400 1 00041          LXA 6A,1               SET IR-1=6                          DPP10209
00247  0 56000 2 00000          LDQ 0,2                GET NEXT PACKED WORD                DPP10210
00250  1 77777 2 00241          TXI XTR4,2,-1          STEP PACKED ADDR.                   DPP10211
00251 -0 53400 1 00433   XTR3   LXD XTRN,1             SET IR-1=N                          DPP10212
00252 -0 50000 0 00243          CAL XTRU               SET ACC(ADR)=(UD+N)                 DPP10213
00253 -0 53400 2 00440          LXD XTRB,2             RESTORE                             DPP10214
00254 -0 53400 4 00441          LXD XTRX,4                 AND                             DPP10215
00255  0 02000 2 00001          TRA 1,2                RETURN                              DPP10216
                                                                                           DPP10217
                                INSERT FIELD FROM UD                                       DPP10218
                                                                                           DPP10219
00256  0 53400 1 00000   INS1   LXA 1A,1               SET IR-1=1                          DPP10220
00257 -0 63400 2 00444   INS    SXD INSB,2             SAVE IR-2,4                         DPP10221
00260 -0 63400 4 00445          SXD INSC,4                                                 DPP10222
00261 -0 63400 1 00434          SXD INSN,1             SAVE N                              DPP10223
```

```
                                                                                   DPP10224
00262  0 07400 2 00165          TSX LFS,2           LOCATE FIELD START             DPP10225
00263  0 76000 0 00006          COM                                                DPP10226
00264  0 73400 2 00000          PAX 0,2             SET IR-2=1COM(A+Q)             DPP10227
00265 -0 50000 0 00434          CAL INSN                                           DPP10228
00266  0 77100 0 00022   INS6   ARS 18                                             DPP10229
00267  0 73400 4 00000          PAX 0,4             SET IR-4=N                     DPP10230
00270  0 40000 0 00035          ADD UDB             (UD+N)                         DPP10231
00271  0 62100 0 00300          STA INSU                                           DPP10232
00272 -0 50000 1 00046          CAL STAB+1,1        SET UP INITIAL SHIFT           DPP10233
00273  0 62100 0 00275          STA INS2                                           DPP10234
00274  0 56000 2 77777          LDQ -1,2            GET FIRST PACKED WORD          DPP10235
00275 -0 76300 0 00000   INS2   LGL ()              INITIAL SPIN                   DPP10236
00276  0 76700 0 00006   INS4   ALS 6                                              DPP10237
00277 -0 77300 0 00006          RQL 6                                              DPP10238
00300  0 36100 4 00000   INSU   ACL (),4            INSERT                         DPP10239
00301 -2 00001 4 00310          TNX INS3,4,1        TEST FOR N CHAR.               DPP10240
00302  2 00001 1 00276          TIX INS4,1,1        TEST FOR 6 CHAR.               DPP10241
00303  0 60200 2 77777          SLW -1,2            STORE PACKED WORD              DPP10242
00304  0 53400 1 00041          LXA 6A,1            SET IR-1=6                     DPP10243
00305  0 56000 2 00000          LDQ 0,2             GET NEXT PACKED WORD           DPP10244
00306  1 77777 2 00276          TXI INS4,2,-1       STEP P.W. ADDR.                DPP10245
00307 -0 76300 0 00006   INS5   LGL 6               SPIN LAST                      DPP10246
00310  2 00001 1 00307   INS3   TIX INS5,1,1        PACKED WORD                    DPP10247
00311  0 60200 2 77777          SLW -1,2                                           DPP10248
00312 -0 53400 2 00444          LXD INSB,2          RESTORE                        DPP10249
00313 -0 53400 4 00445          LXD INSC,4          AND                            DPP10250
00314  0 02000 2 00001          TRA 1,2             RETURN                         DPP10251
00315 -0 63400 2 00444   INSX   SXD INSB,2               SAVE I. R.                DPP10252
00316 -0 63400 4 00445          SXD INSC,4                                         DPP10253
00317 -0 53400 1 00443          LXD XTRR,1               SET IR-1=(6-REM)          DPP10254
00320  0 53400 2 00442          LXA XTRC,2          SET IR-2=1COM(A+Q)             DPP10255
00321 -0 50000 0 00433          CAL XTRN            SET N                          DPP10256
00322  0 02000 0 00266          TRA INS6                                           DPP10257
                                                                                   DPP10258
                                      DECIMAL TO BINARY CONVERSION                 DPP10259
                                                                                   DPP10260
00323 -0 63400 1 00421   DTB    SXD XA,1            SAVE I.R.                      DPP10261
00324 -0 63400 2 00422          SXD XB,2                                           DPP10262
00325  0 50000 4 00001          CLA 1,4             GET N                          DPP10263
00326  0 73400 1 00000          PAX 0,1             SET IR-1=N                     DPP10264
00327  0 14000 0 00330          TOV DB1             TURN OFF OV. TRIGGER           DPP10265
00330  0 50000 4 00002   DB1    CLA 2,4             EXTRACT FIELD                  DPP10266
00331  0 07400 2 00220          TSX XTR,2           TO BE CONVERTED                DPP10267
00332  0 62100 0 00335          STA DB3             SET (UD+N)                     DPP10268
00333  0 60000 0 00424          STZ T1              CLEAR PARTIAL SUM              DPP10269
00334  0 56000 0 00002          LDQ 9A              SET MQ=9                       DPP10270
00335  0 50000 1 00000   DB3    CLA (),1                                           DPP10271
00336  0 04000 0 00347          TLQ DB4             TEST FOR PURE DIGIT            DPP10272
00337  0 40000 0 00424          ADD T1                                             DPP10273
00340 -3 00001 1 00362          TXL DB5,1,1         TEST FOR UNITS DIGIT           DPP10274
00341  0 60100 0 00424          STO T1              PROGRAMMED                     DPP10275
00342  0 76700 0 00003          ALS 3               MULT.                          DPP10276
00343  0 40000 0 00424          ADD T1              BY                             DPP10277
00344  0 40000 0 00424          ADD T1              10                             DPP10278
00345  0 60100 0 00424          STO T1                                             DPP10279
00346  2 00001 1 00335          TIX DB3,1,1
```

```
00347  3 00001 1 00365   DB4    TXH DB6,1,1         TEST FOR UNITS DIGIT           DPP10280
00350  0 73400 2 00000          PAX 0,2             IS UNITS POSITION              DPP10281
00351  0 56000 2 00145          LDQ BCD,2           A SIGNED DIGIT                 DPP10282
00352 -0 77300 0 00001          RQL 1                                              DPP10283
00353  0 16200 0 00365          TQP DB6                                            DPP10284
00354 -0 77300 0 00037          RQL 31              PUT UNSIGNED UNITS             DPP10285
00355  0 50000 0 00040          CLA ZERO            DIGIT IN ACC                   DPP10286
00356 -0 76300 0 00004          LGL 4                                              DPP10287
00357  0 40000 0 00424          ADD T1                                             DPP10288
00360 -0 77300 0 00003          RQL 3               SIGN AC                        DPP10289
00361  0 76300 0 00000          LLS 0                                              DPP10290
00362  0 14000 0 00364   DB5    TOV DB7             OVERFLOW TEST                  DPP10291
00363  1 77774 4 00146          TXI END,4,-4        NORMAL RETURN                  DPP10292
00364  0 50000 0 00016   DB7    CLA 1D              SET DECREMENT TO 1             DPP10293
00365  1 77775 4 00146   DB6    TXI END,4,-3        ERROR RETURN                   DPP10294
                                                                                   DPP10295
                                      BINARY TO DECIMAL CONVERSION                 DPP10296
                                                                                   DPP10297
00366 -0 63400 1 00421   BTD    SXD XA,1            SAVE I.R.                      DPP10298
00367 -0 63400 2 00422          SXD XB,2                                           DPP10299
00370  0 76500 0 00043          LRS 35              SHIFT BINARY INTO MQ           DPP10300
00371  0 76000 0 00000          CLM                                                DPP10301
00372  0 36100 4 00001          ACL 1,4                                            DPP10302
00373  0 73400 1 00000          PAX 0,1             SET IR-1=N                     DPP10303
00374 -0 63400 1 00424          SXD T1,1            SAVE N                         DPP10304
00375  0 36100 0 00036          ACL UDM1                                           DPP10305
00376  0 62100 0 00404          STA BD1             SET (UD+N-1)=UNITS POSITION    DPP10306
00377  0 62100 0 00410          STA BD2                                            DPP10307
00400  0 62100 0 00414          STA BD3                                            DPP10308
00401  0 53400 2 00040          LXA ZERO,2          SET IR-2=0                     DPP10309
00402  0 76000 0 00000   BD5    CLM                                                DPP10310
00403  0 22000 0 00003          DVH 10A             GENERATE BCD                   DPP10311
00404  0 60200 2 00000   BD1    SLW (),2            STORE UNPACKED BCD             DPP10312
00405 -2 00001 1 00407          TNX BD4,1,1         TEST FOR N CHAR.               DPP10313
00406  1 00001 2 00402          TXI BD5,2,1                                        DPP10314
00407  0 12000 0 00415   BD4    TPL BD6             SKIP ON +                      DPP10315
00410  0 50000 0 00000   BD2    CLA ()              -, GET UNITS DIGIT             DPP10316
00411 -0 10000 0 00413          TNZ BD7                                            DPP10317
00412  0 40000 0 00003          ADD 10A                                            DPP10318
00413  0 40000 0 00006   BD7    ADD 040A            SIGN UNITS DIGIT -             DPP10319
00414  0 60100 0 00000   BD3    STO ()                                             DPP10320
00415 -0 53400 1 00424   BD6    LXD T1,1            INSERT BCD                     DPP10321
00416  0 50000 4 00002          CLA 2,4                                            DPP10322
00417  0 07400 2 00257          TSX INS,2                                          DPP10323
00420  1 77775 4 00146          TXI END,4,-3        RETURN                         DPP10324
                                                                                   DPP10325
                                      UNIVERSAL ERASEABLE                          DPP10326
                                                                                   DPP10327
00421  0 00000 0 00000   XA                                                        DPP10328
00422  0 00000 0 00000   XB                                                        DPP10329
00423  0 00000 0 00000   XC                                                        DPP10330
00424  0 00000 0 00000   T1                                                        DPP10331
00425  0 00000 0 00000   T2                                                        DPP10332
00426  0 00000 0 00000   T3                                                        DPP10333
00427  0 00000 0 00000   T4                                                        DPP10334
00430  0 00000 0 00000   T5                                                        DPP10335
```

```
                                                                                                DPP10336
00431  0 00000 0 00000  LFSA                                                                    DPP10337
00432  0 00000 0 00000  SBAB                                                                    DPP10338
00433  0 00000 0 00000  XTRN                                                                    DPP10339
00434  0 00000 0 00000  INSN                                                                    DPP10340
                 00435  IND1  BSS 1                                                             DPP10341
                 00436  LFSB  BSS 1                                                             DPP10342
                 00437  LFSQ  BSS 1                                                             DPP10343
                 00440  XTRB  BSS 1                                                             DPP10344
                 00441  XTRX  BSS 1                                                             DPP10345
                 00442  XTRC  BSS 1                                                             DPP10346
                 00443  XTRR  BSS 1                                                             DPP10347
                 00444  INSB  BSS 1                                                             DPP10348
                 00445  INSC  BSS 1                                                             DPP10349
                 00446  SAC   BSS 1                                                             DPP10350
                 00447  AC    BSS 25                                                            DPP10351
                 00500  UD    BSS U                                                             DPP10352
                                                                                                DPP10353
                 00624        BSS 0                 READ CARD COMPONENT                         DPP10354
                                  READ CARD TO PACKED BCD                                       DPP10355
                                                                                                DPP10356
                 00600  LEFT  SYN UD+64                                                         DPP10357
                 00602  CMN   SYN UD+66                                                         DPP10358
                 00604  BOOL  SYN UD+68                                                         DPP10359
                 00606  8AND  SYN UD+70                                                         DPP10360
                 00610  ATE4  SYN UD+72                                                         DPP10361
                 00612  COBL  SYN UD+74                                                         DPP10362
                 00614  ZAND  SYN UD+76                                                         DPP10363
00624  0 76200 0 00321  RCD   RCD                       SELECT READER                           DPP10364
00625 -0 63400 1 00421        SXD XA,1                  SAVE I. R.                              DPP10365
00626 -0 63400 2 00422        SXD XB,2                                                          DPP10366
00627 -0 63400 4 00423        SXD XC,4                                                          DPP10367
00630 -0 50000 4 00001        CAL 1,4                                                           DPP10368
00631  0 07400 2 00151        TSX INDEX,2               INDEX ADDRESS FOR OUTPUT                DPP10369
00632  0 40100 0 00042        ADM 12A                                                           DPP10370
00633  0 62100 0 00665        STA ORINS                                                         DPP10371
00634  0 62100 0 00636        STA RCD2                                                          DPP10372
00635  0 53400 4 00042        LXA 12A,4                 CLEAR OUTPUT BLOCK                      DPP10373
00636  0 60000 4 00000  RCD2  STZ (),4                                                          DPP10374
00637  2 00001 4 00636        TIX RCD2,4,1                                                      DPP10375
00640  0 53400 4 00005        LXA 64A,4                 SET UP 64 WORD MODEL IN UD BLOCK        DPP10376
00641  0 53400 2 00001        LXA 8A,2                                                          DPP10377
00642  0 53400 1 00001  RCD1  LXA 8A,1                                                          DPP10378
00643 -0 50000 2 01050  CAL   CAL MODEL+8,2                                                     DPP10379
00644  0 76700 0 00022        ALS 18                                                            DPP10380
00645  0 36100 1 01050        ACL MODEL+8,1                                                     DPP10381
00646  0 60200 4 00600        SLW UD+64,4                                                       DPP10382
00647 -2 00001 4 01017        TNX EOF,4,1                                                       DPP10383
00650  2 00001 1 00643        TIX CAL,1,1                                                       DPP10384
00651  2 00001 2 00642        TIX RCD1,2,1                                                      DPP10385
00652  0 70000 0 00600  LOOP  CPY LEFT                  COPY ONE ROW OF THE CARD                DPP10386
00653  0 70000 0 00601  RCD3  CPY LEFT+1                                                        DPP10387
00654  0 53400 2 00041  SUBLP LXA 6A,2                  TAKE ROW 6 BITS AT A TIME               DPP10388
00655  0 56000 0 00600        LDQ LEFT                  AND  (OR) THE APPROPRIATE DIGITS        DPP10389
00656 -0 63400 2 00667        SXD TEST,2                INTO THE OUTPUT BLOCK                   DPP10390
00657  1 00006 2 00660        TXI CLEER,2,6                                                     DPP10391
00660 -0 75400 0 00000T CLEER PXD 0,0
```

```
00661 -0 76300 0 00006        LGL 6                                                             DPP10392
00662  0 73400 1 00000        PAX 0,1                                                           DPP10393
00663 -0 50000 1 00577        CAL UD+63,1                                                       DPP10394
00664 -0 32000 4 01066        ANA NUMB+14,4                                                     DPP10395
00665 -0 60200 2 00000  ORINS ORS (),2                                                          DPP10396
00666 -2 00001 2 00673        TNX TRATA,2,1                                                     DPP10397
00667  3 00000 2 00660D TEST  TXH CLEER,2,()                                                    DPP10398
00670  0 56000 0 00601        LDQ LEFT+1                PROCESS RIGHT HALF OF ROW               DPP10399
00671 -0 63400 0 00667T       SXD TEST,0                                                        DPP10400
00672  0 02000 0 00660        TRA CLEER                                                         DPP10401
00673  1 00001 2 00674  TRATA TXI RCD4,2,1              SET IR-2=2                              DPP10402
00674 -3 00003 4 00752  RCD4  TXL LAST,4,3              IS THIS THE 12 ROW                      DPP10403
00675 -3 00015 4 00705        TXL 8ROW,4,13             IS THIS THE  9 ROW                      DPP10404
00676  0 60000 2 00606  9ROW  STZ BOOL+2,2             INITIALIZE ERASEABLE WORDS              DPP10405
00677  0 60000 2 00604        STZ CMN+2,2                                                       DPP10406
00700  0 60000 2 00610        STZ 8AND+2,2                                                      DPP10407
00701  0 07400 1 01024        TSX OA,1                                                          DPP10408
00702  0 07400 1 01032        TSX OA8,1                                                         DPP10409
00703  2 00001 2 00676        TIX 9ROW,2,1                                                      DPP10410
00704  1 77777 4 00652        TXI LOOP,4,-1                                                     DPP10411
00705 -3 00014 4 00712  8ROW  TXL 7ROW,4,12                                                     DPP10412
00706  0 07400 1 01032  RCD6  TSX OA8,1                                                         DPP10413
00707  0 60200 2 00612        SLW ATE4+2,2                                                      DPP10414
00710  2 00001 2 00706        TIX RCD6,2,1                                                      DPP10415
00711  1 77777 4 00652        TXI LOOP,4,-1                                                     DPP10416
00712 -3 00011 4 00717  7ROW  TXL 4ROW,4,9                                                      DPP10417
00713  0 07400 1 01032  RCD7  TSX OA8,1                                                         DPP10418
00714  0 07400 1 01024  RCD9  TSX OA,1                                                          DPP10419
00715  2 00001 2 00712        TIX 7ROW,2,1                                                      DPP10420
00716  1 77777 4 00652  RCD12 TXI LOOP,4,-1                                                     DPP10421
00717 -3 00010 4 00724  4ROW  TXL 3ROW,4,8                                                      DPP10422
00720  0 07400 1 01024  RCD8  TSX OA,1                                                          DPP10423
00721  0 32000 2 00612        ANS ATE4+2,2                                                      DPP10424
00722  2 00001 2 00720        TIX RCD8,2,1                                                      DPP10425
00723  1 77777 4 00652        TXI LOOP,4,-1                                                     DPP10426
00724  3 00007 4 00714  3ROW  TXH RCD9,4,7                                                      DPP10427
00725  3 00006 4 00713        TXH RCD7,4,6                                                      DPP10428
00726 -3 00005 4 00745  1ROW  TXL ZROW,4,5                                                      DPP10429
00727  0 07400 1 01024  RCD11 TSX OA,1                                                          DPP10430
00730  0 07400 1 01032        TSX OA8,1                                                         DPP10431
00731  2 00001 2 00727        TIX RCD11,2,1                                                     DPP10432
00732  1 00001 2 00733        TXI RCD10,2,1             SET IR-2=2                              DPP10433
00733 -0 50000 2 00610  RCD10 CAL 8AND+2,2                                                      DPP10434
00734  0 70000 2 00610        CPY 8AND+2,2              COPY ZERO ROW INTO 8AND                 DPP10435
00735 -0 50100 2 00604        ORA CMN+2,2               FORM (OR) SUM OF ALL NZ DIGITS          DPP10436
00736 -0 60000 2 00614        STQ COBL+2,2                                                      DPP10437
00737 -0 60200 2 00614        ORS COBL+2,2              FORM (OR) SUM OF ALL DIGITS INCL ZERO   DPP10438
00740 -0 32000 2 00610        ANA 8AND+2,2                                                      DPP10439
00741  0 60200 2 00616        SLW ZAND+2,2              ZAND GETS ALL ZERO ZONES                DPP10440
00742  0 60200 2 00602        SLW LEFT+2,2              GO TO PUT IN ZONE=3                     DPP10441
00743  2 00001 2 00733        TIX RCD10,2,1                                                     DPP10442
00744  1 77777 4 00654        TXI SUBLP,4,-1                                                    DPP10443
00745  3 00004 4 00716  ZROW  TXH RCD12,4,4                                                     DPP10444
00746 -0 50000 2 00602  XROW  CAL LEFT+2,2                                                      DPP10445
00747  0 60200 2 00604        SLW CMN+2,2               CMN GETS ALL 11 PUNCHES                 DPP10446
00750  2 00001 2 00746        TIX XROW,2,1                                                      DPP10447
```

```
00751  1 77777 4 00652          TXI LOOP,4,-1                                                   DPP10448
00752 -3 00002 4 00765   LAST   TXL BLAN,4,2                                                    DPP10449
00753 -0 50000 2 00602   RCD13  CAL LEFT+2,2        CHECK FOR BOTH 11 AND 12 PUNCHES            DPP10450
00754 -0 32000 2 00604          ANA CMN+2,2         IN THE SAME COLUMN                          DPP10451
00755 -0 60200 2 00606          ORS BOOL+2,2                                                    DPP10452
00756 -0 50000 2 00602          CAL LEFT+2,2        CMN GETS ALL 11 OR 12 PUNCHES               DPP10453
00757 -0 50100 2 00604          ORA CMN+2,2                                                     DPP10454
00760  0 60200 2 00604          SLW CMN+2,2                                                     DPP10455
00761 -0 32000 2 00610          ANA 8AND+2,2        GET ALL PLUS OR MINUS ZEROS                 DPP10456
00762  0 60200 2 00602          SLW LEFT+2,2        AND GO TO PUT IN DIGIT OF 12 OCTAL          DPP10457
00763  2 00001 2 00753          TIX RCD13,2,1                                                   DPP10458
00764  1 77777 4 00654          TXI SUBLP,4,-1                                                  DPP10459
00765 -3 00001 4 00777   BLAN   TXL BOO,4,1                                                     DPP10460
00766 -0 50000 2 00604   RCD14  CAL CMN+2,2         FIND ALL COLUMNS WHICH ARE                  DPP10461
00767 -0 50100 2 00614          ORA COBL+2,2        COMPLETELY BLANK                            DPP10462
00770  0 76000 0 00006          COM                                                             DPP10463
00771  0 60200 2 00602          SLW LEFT+2,2                                                    DPP10464
00772  2 00001 2 00766          TIX RCD14,2,1                                                   DPP10465
00773 -0 50100 0 00600          ORA LEFT            UNLESS THERE ARE NO BLANK COLUMNS,          DPP10466
00774  0 10000 0 00776          TZE RCD15           GO TO PUT  IN ZONE=3                        DPP10467
00775  1 77777 4 00654          TXI SUBLP,4,-1                                                  DPP10468
00776  1 77777 4 00777   RCD15  TXI BOO,4,-1                                                    DPP10469
00777 -0 50000 2 00616   BOO    CAL ZAND+2,2        CHECK FOR 8-4 PUNCHES WITH NO ZONE          DPP10470
01000 -0 50100 2 00604          ORA CMN+2,2         THESE ARE TREATED AS ILLEGAL                DPP10471
01001  0 76000 0 00006          COM                                                             DPP10472
01002 -0 32000 2 00612          ANA ATE4+2,2                                                    DPP10473
01003 -0 50100 2 00606          ORA BOOL+2,2                                                    DPP10474
01004  0 60200 2 00602          SLW LEFT+2,2                                                    DPP10475
01005 -0 50000 2 00616          CAL ZAND+2,2        CHECK FOR ZERO ZONE AS WELL AS              DPP10476
01006 -0 32000 2 00604          ANA CMN+2,2         11 OR 12 ZONE IN THE SAME COLUMN            DPP10477
01007 -0 60200 2 00602          ORS LEFT+2,2                                                    DPP10478
01010  2 00001 2 00777          TIX BOO,2,1                                                     DPP10479
01011 -0 50000 0 00600          CAL LEFT                                                        DPP10480
01012 -0 50100 0 00601          ORA LEFT+1                                                      DPP10481
01013 -0 53400 4 00423          LXD XC,4                                                        DPP10482
01014  0 10000 0 01016          TZE RCD16                                                       DPP10483
01015  1 77776 4 00146          TXI END,4,-2        ERROR RETURN                                DPP10484
01016  1 77774 4 00146   RCD16  TXI END,4,-4        NORMAL RETURN                               DPP10485
01017  0 53400 4 00004   EOF    LXA 14A,4           GIVE COPY TO SENSE END OF FILE              DPP10486
01020  0 70000 0 00600          CPY LEFT                                                        DPP10487
01021  0 02000 0 00653          TRA RCD3                                                        DPP10488
01022 -0 53400 4 00423          LXD XC,4            END OF FILE RETURN                          DPP10489
01023  1 77775 4 00146          TXI END,4,-3                                                    DPP10490
01024 -0 50000 2 00602   OA     CAL LEFT+2,2        (AND) ROW TO CMN AND (OR)                   DPP10491
01025 -0 32000 2 00604          ANA CMN+2,2         RESULT TO BOOL                              DPP10492
01026 -0 60200 2 00606          ORS BOOL+2,2                                                    DPP10493
01027 -0 50000 2 00602          CAL LEFT+2,2        (OR) ROW TO CMN                             DPP10494
01030 -0 60200 2 00604          ORS CMN+2,2                                                     DPP10495
01031  0 02000 1 00001          TRA 1,1                                                         DPP10496
01032 -0 50000 2 00602   OA8    CAL LEFT+2,2        (AND) ROW TO 8AND AND (OR)                  DPP10497
01033 -0 32000 2 00610          ANA 8AND+2,2        RESULT TO BOOL                              DPP10498
01034 -0 60200 2 00606          ORS BOOL+2,2                                                    DPP10499
01035 -0 50000 2 00602          CAL LEFT+2,2        (OR) ROW TO 8AND                            DPP10500
01036 -0 60200 2 00610          ORS 8AND+2,2                                                    DPP10501
01037  0 02000 1 00001          TRA 1,1                                                         DPP10502
01040 +000000777777      MODEL  OCT 777777                                                      DPP10503
```

```
01041 +000000777700             OCT 777700                                                      DPP10504
01042 +000000770077             OCT 770077                                                      DPP10505
01043 +000000770000             OCT 770000                                                      DPP10506
01044 +000000007777             OCT 7777                                                        DPP10507
01045 +000000007700             OCT 7700                                                        DPP10508
01046 +000000000077             OCT 77                                                          DPP10509
01047 +000000000000             OCT 0                                                           DPP10510
01050  111111111111      NUMB   BCD 1999999                                                     DPP10511
01051  101010101010             BCD 1888888                                                     DPP10512
01052  070707070707             BCD 1777777                                                     DPP10513
01053  060606060606             BCD 1666666                                                     DPP10514
01054  050505050505             BCD 1555555                                                     DPP10515
01055  040404040404             BCD 1444444                                                     DPP10516
01056  030303030303             BCD 1333333                                                     DPP10517
01057  020202020202             BCD 1222222                                                     DPP10518
01060  010101010101             BCD 1111111                                                     DPP10519
01061  606060606060             BCD 1                                                           DPP10520
01062  404040404040             BCD 1------                                                     DPP10521
01063  202020202020             BCD 1++++++                                                     DPP10522
01064 +121212121212             OCT 121212121212                                                DPP10523
01065  606060606060             BCD 1                                                           DPP10524
01066 -377777777777             OCT 777777777777                                                DPP10525

                  01067         BSS 0               PUNCH PRINT COMPONENT                       DPP10526
                                                                                                DPP10527
                                    PUNCH BCD                                                   DPP10528
                                                                                                DPP10529
01067  0 76600 0 00341   WPU    WPU                 SELECT PUNCH                                DPP10530
01070 -0 63400 1 00421          SXD XA,1            SAVE I.R.                                   DPP10531
01071 -0 63400 2 00422          SXD XB,2                                                        DPP10532
01072 -0 63400 4 00423          SXD XC,4                                                        DPP10533
01073  0 50000 4 00001          CLA 1,4             GET CALL SEQ.                               DPP10534
01074  0 07400 2 00151          TSX INDEX,2         INDEX                                       DPP10535
01075  0 60200 0 01077          SLW PCH3                                                        DPP10536
01076  0 07400 4 01133          TSX DHC,4           GENERATE IMAGE                              DPP10537
01077  0 00000 0 01077   PCH3   HTR PCH3            AND COPY                                    DPP10538
01100 -0 53400 4 00423          LXD XC,4            RETURN                                      DPP10539
01101  1 77776 4 00146          TXI END,4,-2                                                    DPP10540
                                                                                                DPP10541
                                    PRINT BCD                                                   DPP10542
                                                                                                DPP10543
01102  0 76600 0 00361   WPR    WPR                 SELECT PRINTER                              DPP10544
01103 -0 63400 1 00421          SXD XA,1            SAVE I.R.                                   DPP10545
01104 -0 63400 2 00422          SXD XB,2                                                        DPP10546
01105 -0 63400 4 00423          SXD XC,4                                                        DPP10547
01106 -0 50000 4 00001          CAL 1,4             GET CALL SEQ.                               DPP10548
01107 -0 73400 4 00000          PDX 0,4             SET IR-1=W                                  DPP10549
01110  0 07400 2 00151          TSX INDEX,2         INDEX                                       DPP10550
01111  0 60200 0 01114          SLW PRT2            SAVE A,0,W                                  DPP10551
01112  3 00014 4 01117          TXH PRT3,4,12       IS W G.T. 12                                DPP10552
01113  0 07400 4 01133          TSX DHC,4           GENERATE IMAGE                              DPP10553
01114  0 00000 0 01114   PRT2   HTR PRT2            AND COPY                                    DPP10554
01115 -0 53400 4 00423   PRT7   LXD XC,4            RETURN                                      DPP10555
01116  1 77776 4 00146          TXI END,4,-2                                                    DPP10556
01117  0 62100 0 01121   PRT3   STA PRT4            PRINT A,0,12                                DPP10557
01120  0 07400 4 01133          TSX DHC,4                                                       DPP10558
                                                                                                DPP10559
```

```
01121  0 00014 0 00000   PRT4   HTR (),0,12                                               DPP10560
01122  0 76600 0 00361          WPR                     SELECT PRINTER.                   DPP10561
01123  0 76000 0 00371          SPR 9                   KILL SPACING FOR R.H .            DPP10562
01124 -0 50000 0 01114          CAL PRT2                GET (A+12),0,(W-12)               DPP10563
01125  0 36100 0 00042          ACL 12A                                                   DPP10564
01126  0 40200 0 00020          SUB 12D                                                   DPP10565
01127  0 60200 0 01131   PRT5   SLW PRT6                                                  DPP10566
01130  0 07400 4 01133          TSX DHC,4               PRINT RIGHT HALF                  DPP10567
01131  0 00000 0 01131   PRT6   HTR PRT6                WITHOUT SPACING                   DPP10568
01132  0 02000 0 01115          TRA PRT7                                                  DPP10569
                                                                                          DPP10570
                                    PUNCH-PRINT COPY SUBROUTINE                           DPP10571
                                    DECIMAL TO HOLLERITH CONVERSION AND COPIES            DPP10572
                                                                                          DPP10573
                 00524   DH4    SYN UD+20                                                 DPP10574
                 00525   DH6    SYN UD+21                                                 DPP10575
                 00526   DH13   SYN UD+22                                                 DPP10576
                 00527   DH17   SYN UD+23                                                 DPP10577
                                                                                          DPP10578
01133 -0 63400 4 00524   DHC    SXD DH4,4               SAVE IR-4                         DPP10579
01134  0 50000 4 00001          CLA 1,4                 OBTAIN CALL SEQ                   DPP10580
01135  0 40000 0 01201          ADD DH5                 N+1                               DPP10581
01136  0 62200 0 00525          STD DH6                 SAVE N+1                          DPP10582
01137  0 77100 0 00022          ARS. 18                                                   DPP10583
01140  0 40000 4 00001          ADD 1,4                 A + N +1                          DPP10584
01141  0 62100 0 01152          STA DH7                 SAVE                              DPP10585
01142  0 53400 1 01156          LXA DH8,1               SET IR-1=64=OCT100                DPP10586
01143  0 53400 2 01161   DH9    LXA DH10,2              SET IR-2=17=3CT21                 DPP10587
01144  0 60000 3 00621   DH11   STZ UD+81,3             SET IMAGE BLOCK                   DPP10588
01145  2 00001 2 01144          TIX DH11,2,1            TO ZERO                           DPP10589
01146 -0 50000 0 01226          CAL DH12                SET IMAGE BIT                     DPP10590
01147  0 60200 0 00526          SLW DH13                                                  DPP10591
01150  0 53400 2 01203          LXA DH14,2              SET IR-2=6                        DPP10592
01151 -0 53400 4 00525   DH15   LXD DH6,4               SET IR-4=N+1                      DPP10593
01152  0 56000 4 00000   DH7    LDQ 0,4                 OBTAIN PACKED BCD WORD            DPP10594
01153 -2 00001 4 01175          TNX DH16,4,1                                              DPP10595
01154 -0 63400 4 00525          SXD DH6,4               SAVE IR-2,4                       DPP10596
01155 -0 63400 2 00527          SXD DH17,2                                                DPP10597
01156 -0 75400 0 00100T  DH8    PXD 64                  CLEAR AC                          DPP10598
01157 -0 76300 0 00002   DH18   LGL 2                   GET ZONE BITS                     DPP10599
01160  0 73400 2 00000          PAX 0,2                 SET IR-2=ZONE BITS                DPP10600
01161 -0 75400 0 00021T  DH10   PXD 17                  CLEAR AC                          DPP10601
01162 -0 76300 0 00004          LGL 4                   GET DIGIT BITS                    DPP10602
01163  0 73400 4 00000          PAX 0,4                 SET IR-4=DIGIT BITS               DPP10603
01164 -0 50000 0 00526          CAL DH13                                                  DPP10604
01165 -0 60200 3 00620          ORS UD+80,3             OR ZONE BIT TO IMAGE              DPP10605
01166 -0 60200 5 00614          ORS UD+76,5             OR DIGIT BIT TO IMAGE             DPP10606
01167  0 77100 0 00001          ARS 1                   SHIFT IMAGE BIT                   DPP10607
01170  0 60200 0 00526          SLW DH13                                                  DPP10608
01171 -0 32000 0 01227          ANA DH19                TEST FOR 6 CHAR                   DPP10609
01172 -0 10000 0 01156          TNZ DH8                                                   DPP10610
01173 -0 53400 2 00527          LXD DH17,2                                                DPP10611
01174  2 00001 2 01151          TIX DH15,2,1            TEST FOR 36 CHAR                  DPP10612
01175  0 53400 2 01157   DH16   LXA DH18,2              SET IR-2=2                        DPP10613
01176 -0 50000 3 00602   DH20   CAL UD+66,3             FILL IN 8-4 AND                   DPP10614
01177 -0 60200 1 00604          ORS UD+68,1             8-3 BITS                          DPP10615
```

```
01200 -0 60200 3 00612          ORS UD+74,3                                               DPP10616
01201  2 00001 2 01176   DH5    TIX DH20,2,1                                              DPP10617
01202 -0 50000 1 00614          CAL UD+76,1             KILL ZERO ZONE BITS               DPP10618
01203  0 76000 0 00006   DH14   COM                     ON BLANK CHAR                     DPP10619
01204  0 32000 1 00615          ANS UD+77,1                                               DPP10620
01205 -0 50000 1 00614          CAL UD+76,1             ELIMINATE ZERO DIGIT BITS         DPP10621
01206 -0 32000 1 00620          ANA UD+80,1             + AND - CHAR                      DPP10622
01207 -0 50100 1 00615          ORA UD+77,1             TRANSFER ZERO ZONE                DPP10623
01210  0 60200 1 00614          SLW UD+76,1             BITS TO ZERO DIGIT R6             DPP10624
01211 -0 50000 1 00616          CAL UD+78,1             MOVE X Y ZONE BITS                DPP10625
01212  0 60200 1 00615          SLW UD+77,1             INTO COPY POSITION                DPP10626
01213 -0 50000 1 00617          CAL UD+79,1                                               DPP10627
01214  0 60200 1 00616          SLW UD+78,1                                               DPP10628
01215 -0 50000 1 00602          CAL UD+66,1             OBTAIN ZERO BITS                  DPP10629
01216 -0 60200 1 00614          ORS UD+76,1             ON SIGNED ZEROS                   DPP10630
01217  2 00040 1 01143          TIX DH9,1,32                                              DPP10631
01220  0 53400 1 00042          LXA 12A,1                                                 DPP10632
01221  0 70000 1 00517   DH21   CPY UD+15,1             COPY                              DPP10633
01222  0 70000 1 00557          CPY UD+47,1             LOOP                              DPP10634
01223  2 00001 1 01221          TIX DH21,1,1                                              DPP10635
01224 -0 53400 4 00524          LXD DH4,4               RESTORE IR-4                      DPP10636
01225  0 02000 4 00002          TRA 2,4                 RETURN                            DPP10637
01226 -0 00000 0 00000   DH12   MZE                                                       DPP10638
01227 -373737373737      DH19   OCT -373737373737                                         DPP10639
                                                                                          DPP10640
                 01230          BSS 0                   READ WRITE BCD TAPE COMPONENT     DPP10641
                                                                                          DPP10642
                                    READ BCD TAPE                                         DPP10643
                                                                                          DPP10644
01230 -0 63400 1 00421   RTD    SXD XA,1                SAVE INDEX REGS.                  DPP10645
01231 -0 63400 2 00422          SXD XB,2                                                  DPP10646
01232 -0 50000 4 00001          CAL 1,4                 OBTAIN CALL SEQ.                  DPP10647
01233  0 07400 2 00151          TSX INDEX,2             INDEX ORIGIN                      DPP10648
01234  0 76000 0 00006          COM                                                       DPP10649
01235  0 73400 1 00000          PAX 0,1                 SET IR-1=COM(ORIGIN)              DPP10650
01236  0 76000 0 00006          COM                                                       DPP10651
01237  0 77100 0 00022          ARS 18                                                    DPP10652
01240 -0 50100 0 01306          ORA O200A               BUILD TAPE ADDR                   DPP10653
01241  0 62100 0 01242          STA RDT1                                                  DPP10654
01242  0 76200 0 00200   RDT1   RTD ()                  SELECT TAPE                       DPP10655
01243 -0 76000 0 00012   RDT3   RTT                     TURN OFF RTT                      DPP10656
01244  0 76100 0 00000          NOP                                                       DPP10657
01245  0 53400 2 00040          LXA ZERO,2              CLEAR IR-2                        DPP10658
01246  0 70000 1 77777          CPY -1,1                FIRST COPY                        DPP10659
01247  1 00001 2 01253          TXI RDT4,2,1            STEP WORD COUNT                   DPP10660
01250  1 77775 4 00146          TXI END,4,-3            EOF RETURN                        DPP10661
01251  0 76000 0 00000   RDT7   CLM                     FALSE EOR SKIP                    DPP10662
01252  1 77776 4 00146          TXI END,4,-2            FALSE SKIP RETURN                 DPP10663
01253  0 70000 1 00000   RDT4   CPY 0,1                 SUBSEQUENT COPIES                 DPP10664
01254  1 77777 1 01264          TXI RDT6,1,-1           STEP ADDR                         DPP10665
01255  0 02000 0 01251          TRA RDT7                FALSE EOF SKIP                    DPP10666
01256 -0 75400 2 00000          PXD 0,2                 EOR, PLACE WORD COUNT IN AC       DPP10667
01257  0 76600 0 00333          IOD                     I.O. DELAY                        DPP10668
01260 -0 77300 0 00374          RQL 252                 RTT DELAY                         DPP10669
01261 -0 76000 0 00012          RTT                                                       DPP10670
01262  1 77776 4 00146          TXI END,4,-2            ON, TAPE CHECK RETURN             DPP10671
```

```
01263  1 77774 4 00146          TXI END,4,-4          OFF, NORMAL RETURN                  DPP10672
01264  1 00001 2 01253   RDT6   TXI RDT4,2,1          STEP WORD COUNT                     DPP10673
                                                                                          DPP10674
                                    WRITE BCD TAPE                                        DPP10675
                                                                                          DPP10676
01265 -0 63400 1 00421   WTD    SXD XA,1              SAVE I.R.                           DPP10677
01266 -0 63400 2 00422          SXD XB,2                                                  DPP10678
01267 -0 50000 4 00001          CAL 1,4               OBTAIN W                            DPP10679
01270  0 73400 1 00000          PAX 0,1               SET IR-1=W                          DPP10680
01271 -0 50000 4 00002          CAL 2,4               OBTAIN AND INDEX ORIGIN             DPP10681
01272  0 07400 2 00151          TSX INDEX,2                                               DPP10682
01273  0 62100 0 01301          STA WDT1              SET FIRST ADDR.                     DPP10683
01274  0 77100 0 00022          ARS 18                                                    DPP10684
01275 -0 50100 0 01306          ORA O200A                                                 DPP10685
01276  0 62100 0 01277          STA WDT2                                                  DPP10686
01277  0 76600 0 00200   WDT2   WTD ()                SELECT TAPE                         DPP10687
01300 -0 73400 2 00000          PDX 0,2               CLEAR IR-2                          DPP10688
01301  0 70000 2 00000   WDT1   CPY (),2              COPY                                DPP10689
01302 -2 00001 1 01304          TNX WDT3,1,1          W                                   DPP10690
01303  1 77777 2 01301          TXI WDT1,2,-1         WORDS                               DPP10691
01304  0 76600 0 00333   WDT3   IOD                   DELAY USE OF MQ                     DPP10692
01305  1 77775 4 00146          TXI END,4,-3          RETURN                              DPP10693
01306 +000000000200      O200A  OCT 200                                                   DPP10694
                                                                                          DPP10695
            01307               BSS 0                 READ WRITE BINARY TAPE COMPONENT    DPP10696
                                                                                          DPP10697
                                    READ BINARY TAPE                                      DPP10698
                                                                                          DPP10699
01307 -0 63400 2 00422   RTB    SXD XB,2              SAVE IR-2                           DPP10700
01310  0 07400 2 01421          TSX RWBTS,2                                               DPP10701
01311  0 62100 0 01312          STA RTB1                                                  DPP10702
01312  0 76200 0 00220   RTB1   RTB ()                SELECT TAPE                         DPP10703
01313  0 60000 0 00424          STZ T1                CLEAR CHECK SUM                     DPP10704
01314  0 53400 2 01436          LXA 1S,2              SET WORD COUNT=-1                   DPP10705
01315 -0 50000 4 77777          CAL -1,4              GET FIRST C.W.                      DPP10706
01316 -0 73400 1 00000          PDX 0,1               SET IR-1=W                          DPP10707
01317  0 77100 0 00022          ARS 18                                                    DPP10708
01320  0 36100 4 77777          ACL -1,4              (A+W)                               DPP10709
01321  0 62100 0 01324          STA RTB3                                                  DPP10710
01322  0 62100 0 01341          STA RTB4                                                  DPP10711
01323 -0 50000 0 00424          CAL T1                                                    DPP10712
01324 -0 70000 1 00000   RTB3   CAD (),1              FIRST COPY                          DPP10713
01325  1 00001 2 01353          TXI RTB6,2,1          STEP WORD COUNT                     DPP10714
01326  0 02000 0 01332          TRA RTB5              EOF                                 DPP10715
01327  0 76000 0 00000   RTB21  CLM                   FALSE EOR SKIP                      DPP10716
01330 -0 53400 4 00423          LXD XC,4                                                  DPP10717
01331  1 77776 4 00146          TXI END,4,-2          FALSE SKIP RETURN                   DPP10718
01332 -0 53400 4 00423   RTB5   LXD XC,4              EOF RETURN                          DPP10719
01333  1 77775 4 00146          TXI END,4,-3                                              DPP10720
01334 -0 73400 1 00000   RTB12  PDX 0,1               SET IR-1=W                          DPP10721
01335  0 77100 0 00022          ARS 18                                                    DPP10722
01336  0 36100 4 77777          ACL -1,4              (A+W)                               DPP10723
01337  0 62100 0 01341          STA RTB4                                                  DPP10724
01340 -0 50000 0 00424          CAL T1                                                    DPP10725
01341 -0 70000 1 00000   RTB4   CAD (),1                                                  DPP10726
01342  1 00001 2 01353          TXI RTB6,2,1          STEP WORD COUNT                     DPP10727
```

```
01343  0 02000 0 01327          TRA RTB21             FALSE EOF SKIP                      DPP10728
01344  0 76000 0 00006   RTB15  COM                   EOR                                 DPP10729
01345  0 76700 0 00001          ALS 1                                                     DPP10730
01346 -0 53400 4 00423          LXD XC,4              RESTORE IR-4                        DPP10731
01347  0 10000 0 01351          TZE RTB9              CHECK SUM TEST                      DPP10732
01350  1 00002 4 01351          TXI RTB9,4,2          ERROR RETURN                        DPP10733
01351 -0 75400 2 00000   RTB9   PXD 0,2               SET WORD COUNT                      DPP10734
01352  1 77774 4 00146          TXI END,4,-4                                              DPP10735
01353  2 00001 1 01341   RTB6   TIX RTB4,1,1          TEST FOR W WORDS                    DPP10736
01354  0 60200 0 00424          SLW T1                                                    DPP10737
01355  0 50000 4 00000          CLA 0,4               IS THIS LAST                        DPP10738
01356 -0 12000 0 01360          TMI RTB11             CONTROL WORD                        DPP10739
01357  1 77777 4 01334          TXI RTB12,4,-1        STEP C.W. TABLE                     DPP10740
01360 -0 50000 0 00424   RTB11  CAL T1                                                    DPP10741
01361 -0 70000 0 00425          CAD T2                FIRST DUMMY COPY                    DPP10742
01362  0 02000 0 01365          TRA RTB13                                                 DPP10743
01363  0 02000 0 01327          TRA RTB21             FALSE EOF SKIP                      DPP10744
01364  0 02000 0 01344          TRA RTB15             EOR                                 DPP10745
01365 -0 70000 0 00425   RTB13  CAD T2                SUBSEQUENT DUMMY COPIES             DPP10746
01366  0 02000 0 01365          TRA RTB13                                                 DPP10747
01367  0 02000 0 01327          TRA RTB21             FALSE EOF SKIP                      DPP10748
01370  1 00001 2 01344          TXI RTB15,2,1         ADJUST WORD COUNT                   DPP10749
                                                                                          DPP10750
                                    WRITE BINARY TAPE                                     DPP10751
01371 -0 63400 2 00422   WTB    SXD XB,2              SAVE IR-2                           DPP10752
01372  0 07400 2 01421          TSX RWBTS,2           SET UP                              DPP10753
01373  0 62100 0 01374          STA WBT1                                                  DPP10754
01374  0 76600 0 00220   WBT1   WTB ()                SELECT TAPE                         DPP10755
01375  0 60000 0 00424          STZ T1                CLEAR CHECK SUM                     DPP10756
01376 -0 50000 4 77777   WBT5   CAL -1,4              GET CONTROL WORD                    DPP10757
01377  0 62100 0 01403          STA WBT2              SET A                               DPP10758
01400 -0 73400 1 00000          PDX 0,1               SET IR-1=W                          DPP10759
01401 -0 50000 0 00424          CAL T1                GET CHECK SUM                       DPP10760
01402  0 53400 2 00040          LXA ZERO,2            SET IR-2=0                          DPP10761
01403 -0 70000 2 00000   WBT2   CAD (),2              COPY                                DPP10762
01404 -2 00001 1 01406          TNX WBT3,1,1          TEST FOR W WORDS                    DPP10763
01405  1 77777 2 01403          TXI WBT2,2,-1         STEP COPY ADDR.                     DPP10764
01406  0 60200 0 00424   WBT3   SLW T1                SAVE CHECK SUM                      DPP10765
01407  0 50000 4 00000          CLA 0,4               TEST SIGN FOR                       DPP10766
01410 -0 12000 0 01412          TMI WBTB              LAST CONTROL WORD                   DPP10767
01411  1 77777 4 01376          TXI WBT5,4,-1         STEP C.T. ADDR.                     DPP10768
01412 -0 50000 0 00424   WBTB   CAL T1                COPY                                DPP10769
01413  0 76000 0 00006          COM                   COMPLIMENTED                        DPP10770
01414  0 60200 0 00425          SLW T2                CHECK                               DPP10771
01415  0 70000 0 00425          CPY T2                SUM                                 DPP10772
01416 -0 53400 4 00423          LXD XC,4              RESTORE                             DPP10773
01417  0 76600 0 00333          IOD                   DELAY USE OF MQ                     DPP10774
01420  1 77776 4 00146          TXI END,4,-2          RETURN                              DPP10775
                                    READ-WRITE BINARY TAPE SUBROUTINE                     DPP10776
                                                                                          DPP10777
01421 -0 63400 1 00421   RWBTS  SXD XA,1              SAVE IR                             DPP10778
01422 -0 63400 2 00425          SXD T2,2                                                  DPP10779
01423 -0 63400 4 00423          SXD XC,4                                                  DPP10780
01424  0 50000 4 00001          CLA 1,4               GET CALL SEQ.                       DPP10781
01425  0 07400 2 00151          TSX INDEX,2           INDEX                               DPP10782
01426  0 76000 0 00006          COM                                                       DPP10783
```

```
01427  0 73400 4 00000          PAX 0,4                   SET IR-4=COM(C)                    DPP10784
01430  0 76000 0 00006          COM                                                          DPP10785
01431  0 77100 0 00022          ARS 18                    BUILD TAPE ADDR.                   DPP10786
01432 -0 50100 0 01435          ORA 144A                                                     DPP10787
01433 -0 53400 2 00425          LXD T2,2                  EXIT                               DPP10788
01434  0 02000 2 00001          TRA 1,2                                                      DPP10789
                                                                                             DPP10790
01435  0 00000 0 00220   144A       144                                                      DPP10791
01436  0 77777 7 77777   1S     HTR -1,7,-1                                                  DPP10792
                                                                                             DPP10793
                   01437        BSS 0                     MOVE COMPONENT                     DPP10794
                                    MOVE                                                     DPP10795
                                                                                             DPP10796
01437 -0 63400 1 00421   MOV    SXD XA,1                  SAVE I.R.                          DPP10797
01440 -0 63400 2 00422          SXD XB,2                                                     DPP10798
01441 -0 50000 4 00002          CAL 2,4                   GET A                              DPP10799
01442  0 07400 2 00151          TSX INDEX,2               INDEX A                            DPP10800
01443  0 36100 4 00001          ACL 1,4                   A+W                                DPP10801
01444  0 62100 0 01453          STA MOV1                                                     DPP10802
01445 -0 50000 4 00003          CAL 3,4                   GET B                              DPP10803
01446  0 07400 2 00151          TSX INDEX,2               INDEX B                            DPP10804
01447  0 36100 4 00001          ACL 1,4                   B+W                                DPP10805
01450  0 62100 0 01454          STA MOV2                                                     DPP10806
01451 -0 50000 4 00001          CAL 1,4                   GET W                              DPP10807
01452  0 73400 2 00000          PAX 0,2                                                      DPP10808
01453  0 56000 2 00000   MOV1   LDQ (),2                  MOVE                               DPP10809
01454 -0 60000 2 00000   MOV2   STQ (),2                  LOOP                               DPP10810
01455  2 00001 2 01453          TIX MOV1,2,1                                                 DPP10811
01456  1 77774 4 00147          TXI END+1,4,-4            RETURN                             DPP10812
                                                                                             DPP10813
                   01457        BSS 0                     EXTRACT AND INSERT COMPONENT       DPP10814
                                    EXTRACT AND INSERT                                       DPP10815
                                                                                             DPP10816
01457 -0 63400 1 00421   XIN    SXD XA,1                  SAVE I.R.                          DPP10817
01460 -0 63400 2 00422          SXD XB,2                                                     DPP10818
01461  0 50000 4 00001   XIN2   CLA 1,4                                                      DPP10819
01462  0 73400 1 00000          PAX 0,1                   SET IR-1=N                         DPP10820
01463  0 50000 4 00002          CLA 2,4                   EXTRACT                            DPP10821
01464  0 07400 2 00220          TSX XTR,2                                                    DPP10822
01465  0 50000 4 00003          CLA 3,4                   INSERT                             DPP10823
01466  0 07400 2 00257          TSX INS,2                                                    DPP10824
01467  0 50000 4 00003          CLA 3,4                                                      DPP10825
01470 -0 12000 0 01472          TMI XIN1                  TEST FOR LAST EXTRACT-INSERT       DPP10826
01471  1 77775 4 01461          TXI XIN2,4,-3             GET NEXT EXTRACT-INSERT            DPP10827
01472  1 77774 4 00146   XIN1   TXI END,4,-4              RETURN                             DPP10828
                                                                                             DPP10829
                   01473        BSS 0                     ALPHANUMERIC COMPARISON COMPONENT  DPP10830
                                    BCD COMPARISON                                           DPP10831
                                                                                             DPP10832
01473 -0 63400 1 00421   COM    SXD XA,1                  SAVE IR                            DPP10833
01474 -0 63400 2 00422          SXD XB,2                                                     DPP10834
01475  0 50000 4 00001          CLA 1,4                   GET N                              DPP10835
01476  0 73400 1 00000          PAX 0,1                   SET IR-1=N                         DPP10836
01477 -0 50000 4 00003          CAL 3,4                   IF S=0, REPLACE                    DPP10837
01500 -0 73400 2 00000          PDX 0,2                   S BY 1                             DPP10838
01501  3 00000 2 01503D         TXH COM1,2                                                   DPP10839
```

```
01502  0 36100 0 00016          ACL 1D
01503  0 60200 0 00425   COM1   SLW T2                                                       DPP10840
01504 -0 50000 4 00002          CAL 2,4                   SAME FOR R                         DPP10841
01505 -0 73400 2 00000          PDX 0,2                                                      DPP10842
01506  3 00000 2 01510D         TXH COM2,2                                                   DPP10843
01507  0 36100 0 00016          ACL 1D                                                       DPP10844
01510  0 60200 0 00424   COM2   SLW T1                                                       DPP10845
01511 -0 63400 1 00426          SXD T3,1                  SAVE N                             DPP10846
01512 -3 00052 1 01514          TXL COM3,1,U/2            IF N IS G.T. U/2,                  DPP10847
01513  0 53400 1 00032          LXA HUA,1                 SET N=U/2                          DPP10848
01514 -0 63400 1 00427   COM3   SXD T4,1                  SAVE N                             DPP10849
01515  0 07400 2 00220          TSX XTR,2                 EXTRACT FIELD 1                    DPP10850
01516  0 62100 0 01523          STA COM4                  SET (UD+N)                         DPP10851
01517  0 40000 0 00032          ADD HUA                                                      DPP10852
01520  0 62100 0 01524          STA COM5                  SET (UD+U/2+N)                     DPP10853
01521  0 62100 0 01533          STA COM6                                                     DPP10854
01522  0 62100 0 01547          STA COM7                                                     DPP10855
01523  0 56000 1 00000   COM4   LDQ (),1                  MOVE FIELD 1 TO                    DPP10856
01524 -0 60000 1 00000   COM5   STQ (),1                  UPPER HALF OF UD                   DPP10857
01525  2 00001 1 01523          TIX COM4,1,1                                                 DPP10856
01526 -0 53400 1 00427          LXD T4,1                  EXTRACT FIELD 2                    DPP10859
01527 -0 50000 0 00425          CAL T2                                                       DPP10860
01530  0 07400 2 00220          TSX XTR,2                                                    DPP10861
01531  0 62100 0 01534          STA COM8                  SET (UD+N)                         DPP10862
01532  0 62100 0 01555          STA COM9                                                     DPP10863
01533  0 50000 1 00000   COM6   CLA (),1                  COMPARE BCD                        DPP10864
01534  0 40200 1 00000   COM8   SUB (),1                                                     DPP10865
01535 -0 10000 0 01547          TNZ COM7                                                     DPP10866
01536  2 00001 1 01533          TIX COM6,1,1                                                 DPP10867
01537 -0 53400 1 00426          LXD T3,1                  PARTIAL FIELDS EQUAL               DPP10868
01540 -3 00052 1 01565          TXL COM11,1,U/2           IF N IS G.T. U/2,                  DPP10869
01541 -0 50000 0 00425          CAL T2                    WE ARE NOT FINISHED                DPP10870
01542  0 36100 0 00034          ACL HUD                   FORM (B,T,S+U/2)                   DPP10871
01543  0 60200 0 00425          SLW T2                                                       DPP10872
01544 -0 50000 0 00424          CAL T1                    FORM (A,T,R+U/2)                   DPP10873
01545  0 36100 0 00034          ACL HUD                                                      DPP10874
01546  1 77726 1 01510          TXI COM2,1,-U/2           REDUCE N B U/2                     DPP10875
01547  0 50000 1 00000   COM7   CLA (),1                  FIELDS UNEQUAL,                    DPP10876
01550  0 73400 2 00000          PAX 0,2                   COMPARE ORDER                      DPP10877
01551 -0 50000 2 00145          CAL BCD,2                 NUMBERS                            DPP10878
01552  0 10000 0 01567          TZE COM12                 IS CHAR. LEGAL                     DPP10879
01553 -0 32000 0 00021          ANA CXSO                                                     DPP10880
01554  0 60200 0 00430          SLW T5                                                       DPP10881
01555  0 50000 1 00000   COM9   CLA (),1                                                     DPP10882
01556  0 73400 2 00000          PAX 0,2                                                      DPP10883
01557 -0 50000 2 00145          CAL BCD,2                                                    DPP10884
01560  0 10000 0 01567          TZE COM12                 IS CHAR. LEGAL                     DPP10885
01561 -0 32000 0 00021          ANA CXSO                                                     DPP10886
01562  0 40200 0 00430          SUB T5                    2-1                                DPP10887
01563  0 12000 0 01566          TPL COM13                                                    DPP10888
01564  1 77773 4 00146          TXI END,4,-5              1 G. T. 2                          DPP10889
01565  1 77772 4 00146   COM11  TXI END,4,-6              EQUAL RETURN                       DPP10890
01566  1 77771 4 00146   COM13  TXI END,4,-7              1 L. T. 2                          DPP10891
01567  1 77774 4 00146   COM12  TXI END,4,-4              ERROR RETURN                       DPP10892
                                                                                             DPP10893
                                                                                             DPP10894
                                                                                             DPP10895
```

```
02333  0 00000 0 00001    1A         1                                  WDP10224
02334  0 00001 0 00000    1D         0,0,1                              WDP10225
02335  0 00002 0 00000    2D         0,0,2                              WDP10226
02336  0 00003 0 00000    3D         0,0,3                              WDP10227
02337 +000000000220       0220A OCT  220                                WDP10228
02340  0 00000 0 02520    LSTAB      STAB                               WDP10229
02341  0 02000 0 00000    TRA   TRA                                     WDP10230
                                     ERASEABLE                          WDP10231
                 02450    TAB   BES  70                                 WDP10232
                 02474    CTAB1 BES  20                                 WDP10233
                 02520    CTAB2 BES  20                                 WDP10234
                 02520    STAB  BSS  50                                 WDP10235
                 02602    NSC   BSS  1                                  WDP10236
                 02603    NS    BSS  1                                  WDP10237
                 02604    C     BSS  1000                               WDP10238
                 04554    CW2   BSS  1                                  WDP10239
                 04555    9L    BSS  1                                  WDP10240
                 04556    9R    BSS  1                                  WDP10241
                 04557    R1    BSS  1                                  WDP10242
                 04560    R2    BSS  1                                  WDP10243
                 04561    CKS   BSS  1                                  WDP10244
                 04562    LOC   BSS  1                                  WDP10245
                 04563    N     BSS  1                                  WDP10246
                 04564    I     BSS  1                                  WDP10247
                 04565    R     BSS  1                                  WDP10248
                 04566    CS    BSS  1                                  WDP10249
                 04567    DUMP  BSS  1                                  WDP10250
                 04570    CW    BSS  1                                  WDP10251
                 04571    E     BSS  1                                  WDP10252
                 04572    IR    BSS  1                                  WDP10253
                 04573    TRACK BSS  1                                  WDP10254
                 04574    CSC   BSS  1                                  WDP10255
                 04575    COMPN BSS  1                                  WDP10256
                 04576    TEST  BSS  1                                  WDP10257
                 04577    LF    BSS  1                                  WDP10258
                 00000          END                                     WDP10259
```

APPENDIX

OCTAL - CORE STORAGE BCD

For Use With DPP1

Zone / Num.	No Zone		Y		X		0	
No Num.	60	Blank	20	+	40	-		
1	01	1	21	A(+1)	41	J(-1)	61	/
2	02	2	22	B(+2)	42	K(-2)	62	S
3	03	3	23	C(+3)	43	L(-3)	63	T
4	04	4	24	D(+4)	44	M(-4)	64	U
5	05	5	25	E(+5)	45	N(-5)	65	V
6	06	6	26	F(+6)	46	O(-6)	66	W
7	07	7	27	G(+7)	47	P(-7)	67	X
8	10	8	30	H(+8)	50	Q(-8)	70	Y
9	11	9	31	I(+9)	51	R(-9)	71	Z
0	00	0	32	+0	52	-0		
	12	Illegal					72	‡ (Illegal)
8-3	13	=	33	.	53	$	73	,
8-4	14	@(Illegal)	34	)	54	*	74	(
	15	Illegal	35	Illegal	55	Illegal	75	Illegal
	16	Illegal	36	Illegal	56	Illegal	76	Illegal
	17	Illegal	37	Illegal	57	Illegal	77	Illegal

NOTE: The characters $\overset{+}{0}$ (32) and $\overset{-}{0}$ (52) cannot be printed. Moreover, removing the zone bits of $\overset{+}{0}$ or $\overset{-}{0}$ will not yield an unsigned zero.

Eighth, and Last, Plenary Assembly of the C.C.I.T., Geneva, 1956

U.D.C. 061.3:621.394

INTRODUCTION

THE International Telegraph Consultative Committee (C.C.I.T.) held its Eighth, and last, Plenary Assembly in Geneva in December, 1956. The meeting of the Plenary Assembly was preceded by meetings of all the Study Groups to prepare final reports on their work for submission to the Plenary Assembly. The meeting of the Eighth Plenary Assembly of the C.C.I.T. was immediately followed by the First Plenary Assembly of the new International Telegraph and Telephone Consultative Committee (C.C.I.T.T.), which combines the functions of the old separate committees for telegraphy and telephony.

Since the Seventh Plenary Assembly of the C.C.I.T., held in Arnhem in May, 1953,[1] the work of the C.C.I.T. has been carried on through the medium of the Study Groups set up by the Plenary Assembly. Each of these Study Groups has met at least once during the intervening period to study the 80-odd questions remitted to them by the Plenary Assembly.

TECHNICAL DISCUSSION

In general the work of the technical Study Groups of the C.C.I.T. has been concerned with problems associated with the expanding use of switched telegraph services in the international field and the integration of wire- and radio-telegraph services. Broadly, the problems fall into three categories: transmission, telegraph apparatus, and switching apparatus.

In the field of transmission, work has been done with a view to improving and extending the technique and definitions relating to telegraph transmission so as to take better account of the requirements for the measurement, prediction and specification of telegraph distortion and telegraph transmission performance on tandem-connected telegraph channels. These requirements arise mainly from the need for the greatest possible accuracy in the difficult transmission conditions imposed by the international telex service and the need to take account of the different transmission conditions affecting radio circuits as compared with wire-line circuits. As a part of the attack on the problems concerned, the definitions have been extended to include matters concerned with error rates, the probability of the distortion on a circuit exceeding an assigned value, and the effect of signal mutilation as distinct from signal distortion.

Other problems tackled have been the analysis of the various factors contributing to the distortion and signal mutilations arising on international telegraph circuits, and the best methods of measuring, observing and specifying the performance, both of the individual telegraph channels and of the international trunk circuits carrying the multi-channel telegraph systems. This latter aspect of the work has, of course, been undertaken in co-operation with the C.C.I.F. One of the more important points under consideration is the extent to which the performance of the telegraph channels is being degraded by transitory effects leading either to sudden changes in the level, phase or frequency of the transmitted signals or to the transitory occurrence of high-level noise. A strong recommendation has been made that Administrations should actively pursue all practical measures to reduce these disturbances, which ultimately limit the accuracy of transmission possible on international switched telegraph services.

So far as the telegraph channels themselves are concerned, apart from the question of improved testing techniques, methods of improving the performance of amplitude-modulated voice-frequency telegraph systems have been studied as well as factors affecting the introduction of frequency-shift-modulated voice-frequency telegraph systems. While experience must yet be acquired in the use of systems of the latter type in the international service before full standardization can be achieved, it has been recognized that there are potential advantages to be gained from their use, and agreement has been reached on those standards necessary to enable Administrations to proceed to their introduction by mutual agreement. Other questions coming under review included the use of start-stop regenerative repeaters, transmission conditions in national telex networks in relation to the international service, and improvement of fault location and maintenance arrangements and of the facilities for the speedy withdrawal of faulty circuits and equipment from service.

In the field of telegraph apparatus there has been some further standardization of detail, and standards have been agreed in relation to the use of 7-unit error-correcting systems on the radio part of combined wire- and radio-teleprinter communications. The question has been studied of more accurately determining the transmission performance of telegraph apparatus installed at subscribers' premises, by means of measurements carried out at the telex exchange. Among the new questions set for study is one related to a possible need for extending the facilities offered by the present 5-unit telegraph alphabet, perhaps by the introduction, under agreed conditions, of a 6-unit code.

In telegraph switching the most important problems under study were those related to the introduction of subscriber-to-subscriber dialling in the international telex service. Despite the fact that two somewhat different systems of signalling, with individual variants, have come into use—one normally (although not necessarily) associated with dial selection, and the other normally associated with teleprinter keyboard selection—a large measure of standardization has been agreed upon as well as a basis on which the different systems can co-operate. This should allow the process of providing full subscriber-to-subscriber dialling in the international telex service to proceed without undue technical difficulty. Further standardization is, however, desirable and the study is being continued to this end. Recommendations have also been issued in connexion with numbering schemes, standardization of dial pulses, and the utilization, in switched telegraph services, of circuits including radio links employing error-correcting systems. New questions for study include the means of barring certain classes of international communication in automatically-switched networks, methods of selectively inserting regenerative repeaters, and signalling standards for the proposed European switching network for the general public telegraph service.

A special mixed exploitation and technical Study Group was set up at Arnhem to consider the problem of establishing a switched network for the general public telegraph service in Europe. The problem was complicated by the fact that some countries were already operating a combined switched network for their telex and national general telegraph services, while others had separate switched networks for the two services. In addition, some countries envisaged the connexion of the national switched networks to the international general telegraph switched network, while others envisaged connexions to the international network only by means of specialized exchanges. The setting up of a network incorporating all these possibilities has therefore had to be catered for. A number of important recommendations have been issued covering the principles upon which the the proposed network should be established and operated, and these are sufficient to enable a start to be made with the building up of an international service. As a result, the work of the mixed Study Group has been considered as terminated, outstanding problems being left for study by the appropriate exploitation or technical Study Group. On the technical side, the more important problems outstanding are the standardization of the signalling conditions and agreement as to the technical means to be adopted to prevent telex subscribers obtaining access to telegraph offices in another country.

---

[1] *P.O.E.E.J.*, Vol. 46, p. 121, Oct. 1953.

The Post Office Electrical Engineers' Journal vol 50 part 1 April 1957

In the field of facsimile and photo-telegraphy a revision was undertaken of the existing recommendations to bring them up to date and, in particular, to take account of the possible use of frequency modulation as an alternative to amplitude modulation. Means of increasing the speed of photo-telegraph transmission on modern carrier telephone circuits have also been considered, but further experience is necessary. The question of the facsimile transmission of weather charts was also studied and a report on the subject prepared for transmission to the World Meteorological Organization. An important recommendation was issued defining the direction of scanning for all direct recording facsimile systems. New questions set for study relate to such subjects as the possible use of asymmetric sideband operation on metallic telephone circuits for increasing the speed of facsimile transmission, methods of recording facsimile signals with a view to their re-transmission, and the possible introduction of a new international service for the facsimile transmission between subscribers of business documents.

CONCLUSION

The Plenary Assembly of the C.C.I.T. was immediately followed by the First Plenary Assembly of the new International Telegraph and Telephone Consultative Committee (C.C.I.T.T.), at which the Study Group organization for the new Committee was determined. From the telegraph point of view the main changes were that, as part of a plan to reduce the number of Study Groups, the facsimile and photo-telegraph group was amalgamated with the telegraph apparatus group, and the whole of the Study Groups dealing with exploitation and tariffs for telegraphs were combined as one Sub Study Group of a main Study Group charged with the co-ordination of all exploitation and tariff questions. To improve the co-ordination of transmission problems a sub-group of the main Study Group for line transmission was established to deal with questions related to the use of international lines for telegraphy.

E. H. J.

◆

The XVIIIth, and Final, Plenary Assembly of the C.C.I.F., Geneva, December, 1956

U.D.C. 061.3:621.395

INTRODUCTION

THE International Telephone Consultative Committee (C.C.I.F.) held its XVIIIth, and final, Plenary Assembly at Geneva in December, 1956. The Plenary Assembly was preceded by meetings of all the Study Groups of the C.C.I.F., and a brief account is given in these notes of the work of the Study Groups since the XVIIth Plenary Assembly[1] at Geneva in October, 1954. After the XVIIIth Plenary Assembly of the C.C.I.F., the First Plenary Assembly was held of the new Committee that now combines the functions of the old C.C.I.F. and C.C.I.T.—the International Telegraph and Telephone Consultative Committee (C.C.I.T.T.).

In addition to the winding-up of the C.C.I.F., the closing stages of the XVIIIth Plenary Assembly was the occasion for a formal farewell to M. Georges Valensi, Director of the C.C.I.F., who was retiring from International Telecommunication Union activities.

FIRST STUDY GROUP—PROTECTION FROM INTERFERENCE CAUSED BY POWER LINES

This Study Group pursued the study of 24 questions. Its work was primarily concerned with the co-existence of power transmission and distribution systems, including electrified railways, and telecommunication lines. Current developments in the transmission of electric power by very high voltage a.c. and d.c. systems, including long undersea links, and the increasing use of 50-c/s a.c. for railway traction, are typical matters that engaged the attention of this group. Another question considered was the risk to which underground telecommunication lines are exposed when high earth potentials, due to power system faults, occur in their vicinity. This question is of particular interest when telecommunication circuits are taken into power stations or high-voltage switching stations.

A further matter considered was the elimination of noise in telecommunication circuits in cables when the sheaths of the cables are connected to power cables, water or gas pipes, pipe lines or electrified railways to effect a communal cathodic protection scheme.

In addition to the above, a sub-committee of the group had been revising the current "Directives concerning the protection of telecommunication lines against the adverse effects of electric power lines." Three meetings of this sub-committee had been held since 1955. The work will be carried to completion by the appropriate study group of the new organization.

Other work in hand was the revision of the current Volume II of the C.C.I.F. Green Book, setting out the recommendations for the protection of telecommunication lines and the constitution of telephone cable sheaths. This work was being carried out in co-operation with Study Group 2.

SECOND STUDY GROUP—PROTECTION AGAINST CORROSION

The program of this Study Group covered a range of 19 questions. Of these, that dealing with the impregnation of wooden poles seems to have given rise to considerable interest. It has been suggested that it would be useful to publish a summary of information on this subject. This task will be undertaken by a working party of the new C.C.I.T.T. study group concerned.

Consideration was also given to the problems of cables with entirely plastic sheaths; cables having the conductors insulated with paper and plastic materials were dealt with separately. A further subject under study was the problem of protecting underground cables against lightning.

---

[1] *P.O.E.E.J.*, Vol. 47, p. 239, Jan. 1955.

The Work of the International Telecommunication Union in the Field of Telephony

W. E. BLOECKER
MEMBER AIEE

G. A. CALDWELL
MEMBER AIEE

FEW ENGINEERS in North America are familiar with the work of the International Telecommunication Union or are even aware of its existence. This paper discusses the Union; its organization, how it functions, and what it is doing in the field of telephony. It also gives an assessment of the value of this work and an appraisal of its significance to the communication developments in the United States and Canada.

It is trite to say these days that the world is becoming smaller. Certainly telecommunications are helping make it so in the ease by which the expression of thought may be transmitted without distortion between nations and continents, and by the medium this provides for the achievement of ready understanding. As it affects the engineer, when such a medium becomes available to all men, he has to be aware of the influence of his thinking and his progress in achieving his objectives on his own environment, on his co-ordinates in other areas, and of their influence on him. The International Consultative Committee activities described here provide an instrument essential to this realization on a universal basis.

It is especially opportune to review this field of activity now, since, on January 1, 1957, the Consultative Committees on Telegraphy and Telephony were reorganized into a new single committee covering both fields.

Historical Background

The International Telecommunication Union is the existing symbol of international co-operation to provide a favorable climate for the development of the world-wide communication network as it is known today. It is a comparatively young body, having been established at Madrid, Spain, in 1932. Its ancestors go back much further, the International Telegraph Union dating from 1865 and the International Radiotelegraph Union from 1903.

The first seeds, however, were planted even earlier in central Europe; the first agreement on record, drawn by Prussia and Austria in the latter part of 1849, tied together the telegraph networks of those two countries. Within a few months similar bilateral agreements were made between Prussia and Saxony, and between Austria and Bavaria. All of these agreements classified and regulated telegraph traffic between the contracting governments. It is of interest that originally they were established to meet military and other governmental needs, and provided for public messages only to the extent and during the periods that facilities might be available.

The next logical step came within a year when these four states entered into the Austro-German Telegraph Union covering the mutual interchange of traffic. By the end of 1854 this group grew to include the Netherlands and four additional German states.

Meanwhile in western Europe, France concluded similar bilateral agreements with its neighbors Belgium, Switzerland, Sardinia, and Spain. These five states soon saw the advantages of a joint agreement and in 1855 created the Western European Telegraph Union.

It was probably inevitable that relations would be established between members of these two groups. Thus it was in 1852 that a third grouping developed when Prussia, Belgium, and France signed a Convention* regulating their mutual correspondence. By 1861 this group attracted as adherents 11 additional states.

The next big move was initiated by France in 1864 when all the major countries of Europe were invited to Paris. Twenty states responded. Out of this came the International Telegraph Union whose Convention was signed in 1865.

This union enjoyed an ever-widening sphere of influence. Asia Minor was included in 1863, Persia and India in 1868, Great Britain in 1872. At a meeting in 1875 Egypt was present under its own identity and Japan and the United States sent observers. By 1882 all areas of the world were represented, with the United States still in the role of observer.

Meanwhile the telephone had been invented in 1876, and by 1885 several international lines were in existence in Europe. At the Berlin (Germany) Telegraph Conference of 1885, the first steps were taken in the regulation of international telephone traffic.

By 1924, and especially in the period following the close of World War I, telephony had made great progress and was expanding at an increasing rate. In that year, in recognition of the need for an organization which would afford means for having meetings at which experts of various countries could consider the technical and operating problems of the European telephone system there was created the International Consultative Committee for Long Distance Telephony. In the 1925 Paris Conference of the International Telegraph Union, the Telephone Consultative Committee was brought into the Union as a semi-independent body. At the same meeting a similar Consultative committee for telegraph communications was established.

With the development of radio as a practical means of communication around the end of the 19th century, international co-operative action was initiated in the Berlin Conference of 1903 to work out problems to assure unhindered international radio communication. At that time safety of life at sea was a prime consideration. Nine countries, including the United States, attended. In a second Berlin Conference in 1906, an International Radiotelegraph Convention and Associated Radio Regulations were adopted by 29 countries.

The International Radiotelegraph Conference at Washington, D. C., in 1927, established the International Consultative Committee for Radio Communications, with similar aims as those already established for telegraphy and telephony.

As radio grew its political and economic effects became so great that no nation could afford to ignore them; by 1932 the International Radiotelegraph Union

---

* "Convention" as used here, and in international affairs generally, means a multiparty treaty to which governments are signatory.

Paper 57-785, recommended by the AIEE Wire Communications Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24–28, 1957. Manuscript submitted March 27, 1957; made available for printing April 30, 1957.

W. E. Bloecker is with the American Telephone and Telegraph Company, New York, N. Y., and G. A. Caldwell is with the Bell Telephone Company of Canada, Ltd., Montreal, Que., Canada.

Communication And Electronics Nov 1957 #33 membership included almost every civilized nation on the globe.

The stage was now set for the final welding of world-wide communications under a single body. At Madrid in 1932, the 13th International Telegraph Conference and the fourth International Radiotelegraph Conference met simultaneously. A liaison was achieved for consideration of common questions; by joint meetings of the two Plenary Assemblies and by Joint Conference Committees. The most important achievement of the Madrid conference was the creation of a single Convention, containing the general principles common to the telegraph, telephone, and radio services. Thus was created the International Telecommunication Union.

The International Telecommunication Union

The International Telecommunication Union is recognized by the United Nations as the specialized agency responsible for taking such action as may be appropriate in the fulfillment of its purposes. Its fundamental basis of operation is the International Telecommunication Convention, the latest revision of which is that adopted at the Plenipotentiary Conference at Buenos Aires, Argentina, in 1952. This Convention was signed by delegates of 78 countries and territories of the world and subsequently ratified by practically all of the countries of the world.

To round out the provisions of the Convention, there are four sets of Administrative Regulations—Telegraph, Telephone, Radio, and Additional Radio—which are concerned with detailed relationships between correspondent countries in international communications. Many of the countries signatory to the Convention have officially indicated reservations regarding observance of one or more of these sets of regulations. These positions arise out of situations peculiar in those countries on international services. The United States and Canada are among those countries which have not adhered to the Telephone and Additional Radio Regulations because they include operating and rate matters based principally on European practices, and because these matters are the concern primarily of the operating agencies handling the communication services, rather than the governments themselves. This subject will be considered further in a later part of the paper.

MEMBERSHIP

Membership is open to any sovereign country and group of territories in the world, which meet certain general qualifications set down in the Convention.

Members are entitled to participate in conferences of the Union and are eligible to any permanent organ of the Union. Each member, large or small, has one vote in conferences and meetings.

PURPOSES OF THE UNION

The purposes of the Union are spelled out in the Convention and are quoted here in full:

1. The purposes of the Union are:
   - (*a*) to maintain and extend international co-operation for the improvement and rational use of telecommunication of all kinds;
   - (*b*) to promote the development of technical facilities and their most efficient operation with a view to improving the efficiency of telecommunication services, increasing their usefulness and making them, so far as possible, generally available to the public;
   - (*c*) to harmonize the actions of nations in the attainment of those common ends.

2. To this end, the Union shall in particular:
   - (*a*) effect allocation of the radio-frequency spectrum and registration of radio-frequency assignments in order to avoid harmful interference between radio stations of different countries;
   - (*b*) foster collaboration among its Members and Associate Members with a view to the establishment of rates at levels as low as possible consistent with an efficient service and taking into account the necessity for maintaining independent financial administration of telecommunication on a sound basis;
   - (*c*) promote the adoption of measures for ensuring the safety of life through the co-operation of telecommunication service;
   - (*d*) undertake studies, formulate recommendations and collect and publish information on telecommunication matters for the benefit of all Members and Associate Members.

STRUCTURE OF THE UNION

The purposes of the Union form a fairly comprehensive directive. The magnitude of the task is pointed up by the character of the membership-peoples of the five continents of the world with their widely varying cultural, social, and economic development. To carry out these objectives calls for a well-considered organization which will provide for an amicable exchange of views, the resolution of differences, and the development of recommendations applicable and acceptable to the wide range of telecommunication needs of the members.

The organization must also be [illegible] enough to adapt itself to the changes of this rapidly changing world in which communications is such a vital part; this must be accomplished by a [illegible] with broad powers to act in the interim between Plenipotentiary Conferences.

The present organization of the Union may be thought of as comprising two broad fields of endeavor. One of these is administrative, to assure that the purposes for which the Union was established are fruitfully being carried out; the other is technical, to provide for studies and the interchange of ideas relating to the engineering and operation of communication systems.

The organization of the Union is shown in Fig. 1. It consists of the following.

Plenipotentiary Conference

This is an international meeting of governments at the diplomatic level. It is the supreme organ of the Union. It provides general direction, establishes the budget and salary scales, elects members of the Administrative Council, revises the Convention as necessary, and makes agreements with other international organizations. It normally meets at 5-year intervals but the date may be changed with the consent of at least 20 members. (Its next meeting is now tentatively scheduled for 1959, after an interval of 7 years.)

Administrative Conference

This, too, is an international meeting at government level, normally convened at the same time and place as the Plenipotentiary Conference. Its primary function is to revise the Regulations annexed to the Convention. Provision is made for calling extraordinary and special administrative conferences with particular agenda.

Administrative Council

This body is composed of 18 members elected by the Plenipotentiary Conference. It may be considered as somewhat analogous to a board of directors. Meeting annually, its job is to see that the work of the Union proceeds smoothly within the boundaries of the Convention and the Regulations. It also has the power to conclude provisional agreements with other international bodies, subject to ratification at the following Plenipotentiary Conference.

General Secretariat

The duties of this organ are implicit [illegible] its title. It may be likened to the business office and general service departments of large companies.

International Frequency Registration Board

This provides an internationally recognized record of radio-frequency assignments made by the different countries, together with the date, purpose, and technical character of each assignment. It furnishes member countries advice with a view to the operation of the maximum practicable number of radio channels in those portions of the spectrum where harmful interference may occur.

International Consultative Committee

The technical and operational features of communication services are the fields of study and recommendations of the International Consultative Committees. These bodies form the focal point of interest in this paper since their work is almost exclusively technical and professional.

The Buenos Aires Convention of 1952 continued the three Consultative Committees: Telegraph, CCIT (Comité Consultatif International Télégraphique); Telephone, CCIF (Comité Consultatif International Téléphonique); Radio, CCIR (Comité Consultatif International des Radiocommunications).

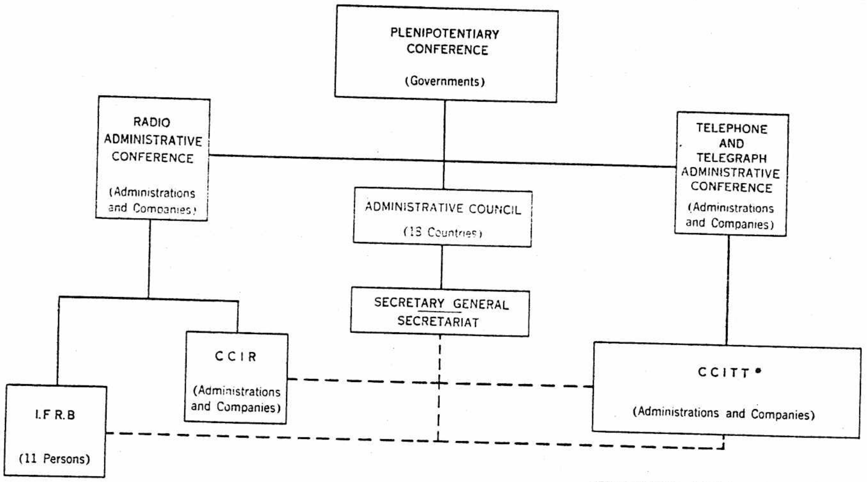
The question of combining the telegraph and telephone activities under a single consultative committee had long been debated. Following World War II, agitation for this move increased, and the 1952 Convention provided for the eventual merger of CCIF and CCIT.

Finally, in 1955, the members of the Union voted by telegraph ballot to merge the activities of CCIF and CCIT into a new International Telegraph and Telephone Consultative Committee to be known as CCITT (from the French equivalent of its name). This merger was effective as of January 1, 1957.

Membership in the Consultative Committees is available as a matter of right to members of the Union as prescribed by the convention.

From the discussion so far, it is evident that membership in the Union is reserved to governments of sovereign states and their territories. There are, however, [illegible] areas of the world, with well over [illegible] of the world's telephones, in which the operation of telephone services is conducted wholly or in part by private enterprise or a public corporation rather than by a department of the government. Included in this list are the United States, Canada, Mexico, Cuba, Chile, Spain, and Japan. In order to make it possible for such organizations to participate in the work of the Union for the good of all, provision is made for their respective governments to certify these private communication companies to membership in the Consultative Committees. These are known as Recognized Private Operating Agencies, and enjoy the full rights of membership, including, in the absence of any representative of their government, the right to vote. By invitation of the International Telephone Consultative Committee and with the concurrence of the State Department, the American Telephone and Telegraph Company has been a member of CCIF since 1929. In 1954 the Government of Canada accredited the Telephone Association of Canada (representing over 90% of the telephone development in the Dominion) as a Recognized Private Operating Agency to be a member of this Consultative Committee.

In many areas of the world the major portion of research and development of new systems and apparatus is carried out in the laboratories associated with equipment manufacturers. They obviously have much to contribute to the work of the Consultative Committees. In order to take advantage of this knowledge, representatives of manufacturers accredited by their governments, are granted membership as experts in the study groups charged with a wide variety of technical problems. They may participate under their own company's identity or as experts attached to the delegations of member administrations. In either capacity they make valuable contributions to the solution of problems which lead to the ultimate recommendations of the Study Group. However, since the Consultative Committees function in the interest of the operating communication services, both government and private, the manufacturers do not attend Plenary Meetings nor do they have the right to vote.


PLENIPOTENTIARY CONFERENCE
(Governments)
RADIO ADMINISTRATIVE CONFERENCE
(Administrations and Companies)
TELEPHONE AND TELEGRAPH ADMINISTRATIVE CONFERENCE
(Administrations and Companies)
ADMINISTRATIVE COUNCIL
(18 Countries)
SECRETARY GENERAL SECRETARIAT
C C I R
(Administrations and Companies)
C C I T T *
(Administrations and Companies)
I.F R.B
(11 Persons)

*Formed by Merger of C.C I F and C.C.I T Effective January 1, 1957

Fig. 1. Organization of International Telecommunication Union

Finances of the Union

Expenses of the Union which currently run in the order of about $\$1^1/_2$ million annually, are classified as ordinary and extraordinary. The former covers expenses of the Administrative Council, of the General Secretariat, of the International Frequency Registration Board, and of the Consultative Committees. They are borne by Members and Associate Members.

The extraordinary expenses are defined as all expenses pertaining to Plenipotentiary Conferences, Administrative Conferences, and meetings of the International Consultative Committees. These expenses are borne by participating governments, Recognized Private Operating Agencies, and scientific and industrial organizations which have agreed to participate in these conferences and meetings or which have actually participated.

Apportionment of the expenses of participants in the work of the Consultative Committee is decided on the basis of the classification chosen by the participant. These range from a 30-unit classification to one of 1/2 unit. The expense allocated to a particular member is determined by the ratio of the number of units in the class the participant has chosen to the number of units represented by the total participants.

The estimated total extraordinary expenditure of the CCITT based on Study Group activities for each of 1957

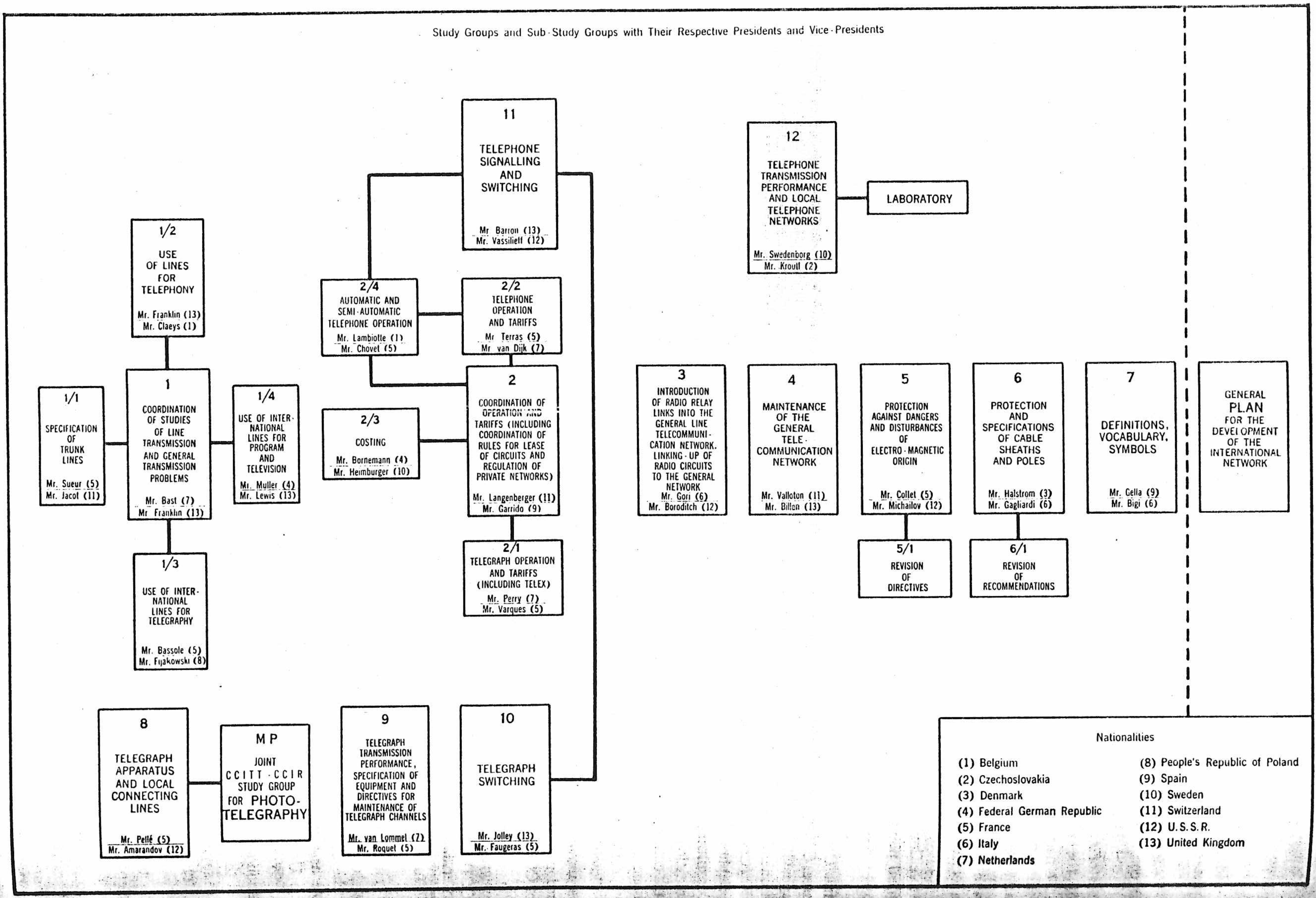

Study Groups and Sub-Study Groups with Their Respective Presidents and Vice-Presidents
1/1
SPECIFICATION OF TRUNK LINES
Mr. Sueur (5)
Mr. Jacot (11)
1/2
USE OF LINES FOR TELEPHONY
Mr. Franklin (13)
Mr. Claeys (1)
1
COORDINATION OF STUDIES OF LINE TRANSMISSION AND GENERAL TRANSMISSION PROBLEMS
Mr. Bast (7)
Mr. Franklin (13)
1/3
USE OF INTERNATIONAL LINES FOR TELEGRAPHY
Mr. Bassole (5)
Mr. Fijakowski (8)
1/4
USE OF INTERNATIONAL LINES FOR PROGRAM AND TELEVISION
Mr. Muller (4)
Mr. Lewis (13)
2/4
AUTOMATIC AND SEMI-AUTOMATIC TELEPHONE OPERATION
Mr. Lambiotte (1)
Mr. Chovet (5)
2/3
COSTING
Mr. Bornemann (4)
Mr. Heimburger (10)
11
TELEPHONE SIGNALLING AND SWITCHING
Mr. Barron (13)
Mr. Vassilieff (12)
2/2
TELEPHONE OPERATION AND TARIFFS
Mr. Terras (5)
Mr. van Dijk (7)
2
COORDINATION OF OPERATION AND TARIFFS (INCLUDING COORDINATION OF RULES FOR LEASE OF CIRCUITS AND REGULATION OF PRIVATE NETWORKS)
Mr. Langenberger (11)
Mr. Garrido (9)
2/1
TELEGRAPH OPERATION AND TARIFFS (INCLUDING TELEX)
Mr. Perry (7)
Mr. Varques (5)
8
TELEGRAPH APPARATUS AND LOCAL CONNECTING LINES
Mr. Pellé (5)
Mr. Amarandov (12)
MP
JOINT CCITT-CCIR STUDY GROUP FOR PHOTO-TELEGRAPHY
9
TELEGRAPH TRANSMISSION PERFORMANCE, SPECIFICATION OF EQUIPMENT AND DIRECTIVES FOR MAINTENANCE OF TELEGRAPH CHANNELS
Mr. van Lommel (7)
Mr. Roquet (5)
10
TELEGRAPH SWITCHING
Mr. Jolley (13)
Mr. Faugeras (5)
12
TELEPHONE TRANSMISSION PERFORMANCE AND LOCAL TELEPHONE NETWORKS
Mr. Swedenborg (10)
Mr. Kroull (2)
LABORATORY
3
INTRODUCTION OF RADIO RELAY LINKS INTO THE GENERAL LINE TELECOMMUNICATION NETWORK. LINKING-UP OF RADIO CIRCUITS TO THE GENERAL NETWORK
Mr. Gori (6)
Mr. Boroditch (12)
4
MAINTENANCE OF THE GENERAL TELECOMMUNICATION NETWORK
Mr. Valloton (11)
Mr. Billen (13)
5
PROTECTION AGAINST DANGERS AND DISTURBANCES OF ELECTRO-MAGNETIC ORIGIN
Mr. Collet (5)
Mr. Michailov (12)
5/1
REVISION OF DIRECTIVES
6
PROTECTION AND SPECIFICATIONS OF CABLE SHEATHS AND POLES
Mr. Halstrom (3)
Mr. Gagliardi (6)
6/1
REVISION OF RECOMMENDATIONS
7
DEFINITIONS, VOCABULARY, SYMBOLS
Mr. Cella (9)
Mr. Bigi (6)
GENERAL PLAN FOR THE DEVELOPMENT OF THE INTERNATIONAL NETWORK
Nationalities
(1) Belgium
(2) Czechoslovakia
(3) Denmark
(4) Federal German Republic
(5) France
(6) Italy
(7) Netherlands
(8) People's Republic of Poland
(9) Spain
(10) Sweden
(11) Switzerland
(12) U.S.S.R.
(13) United Kingdom

Fig. 8. Organization of the International Telegraph and Telephone Consultative Committee.

Fig. 2. Organization of the International Telegraph and Telephone Consultative Committee

1958 is about $50,000 to $60,000 and 1959, the year of the next Plenary Assembly, about $100,000. The total number of units represented at the 1956 Plenary Assembly was $501^1/_2$. Assuming approximately the same level in 1959, the expenses of a participant in the unit class would be about $6,000 and the 1/2-unit class about $100.

International Telegraph and Telephone Consultative Committee

With this background on the Union and the Technical Consultative Committees we can now turn to the central theme of the paper, the field of telephony. For over 30 years studies of technical and operating questions relating to international telephone service have been ably co-ordinated by the International Consultative Committee for Telephony, the CCIF. In the future its destiny will rest with CCITT, the newly created International Consultative Committee for Telegraphy and Telephony.

In December 1956 there were held at Geneva, Switzerland, the VIIIth and final Plenary Assembly of the CCIT, the XVIIIth and final Plenary Assembly of the CCIF, and the first Plenary Assembly of the CCITT. For the CCIF and CCIT these Plenary Assemblies concluded their respective affairs, and proposed a program for the future work of the new CCITT. For this new body, there were the tasks of organization, the election of a Director, and the establishment of a program of work and future meetings.

ORGANIZATION

Plenary Assembly

The Plenary Assembly is the supreme authority of the Consultative Committees. Among its duties are the election of a Director, the establishment of Study Groups and Substudy Groups to carry on its work, the approval of a work program, the approval of recommendations of the technical Study Groups, and the financial requirements of the Consultative Committee.

By provision of the Convention, the Plenary Assembly is normally held at [illegible] intervals.

Study Groups

The real work of the Consultative Committee is accomplished in Study Groups, of which there is one for each of the broad areas of telephone and telegraph engineering and operations. In the larger and more complex areas, the work is divided among Substudy Groups.

The first CCITT Plenary Assembly established its Study Groups and Substudy Groups and assigned to each its tasks. This organization is shown in Fig. 2, which includes also the names and nationalities of the respective Presidents and Vice-Presidents who were appointed by the Plenary Assembly. This arrangement is very similar to that which existed under the CCIF and CCIT for 25 years or more, with consolidations in areas of mutual interest.

The Study Groups and Substudy Groups are permanent bodies of the Consultative Committee. They work through correspondence and meetings. Generally speaking, they range in size from about 20 to 30 members, with attendance at meetings of delegates and experts ranging from 30 or so to well over 100. The larger groups would obviously labor under extreme difficulties in trying to resolve complex questions, such as the design parameters of a coaxial cable system. To handle such problems, Working Groups composed of a small number of well-qualified experts are created. These, set up for specific limited tasks, are temporary, and are disbanded when they have reported their findings back to the Study Group or Substudy Group which had created them.

Language

By the provisions of the Convention the official languages of the Union are English, French, Spanish, Russian, and Chinese. In the smaller Study Groups or Working Party meetings, agreement is usually obtained to conduct the work in French and English with consecutive translation. While this might appear cumbersome, it actually works quite well due in larger measure to the competence of the interpreters and their knowledge of the technical terminology of telephony.

For the 1956 Plenary Assembly at Geneva and the larger study groups meeting immediately preceding it, simultaneous translation facilities were made available. In these meetings the proceedings were conducted by agreement in English, French, Spanish, and Russian. This did not seem to cause any particular difficulty for the Chinese delegates who were well versed in English.

The Director

The Director elected by the Plenary Assembly co-ordinates the work of the Consultative Committee, including its Plenary Assembly and Study Groups, and is responsible for the documents of the committee.

He is assisted by the Secretariat. He participates in an advisory capacity in meetings of the Plenary Assembly and of the Study Groups; submits to the Plenary Assembly a report on the activities of the Consultative Committee since the previous meeting; and also submits for approval a report on the financial needs of the committee up to the next following Plenary Assembly.

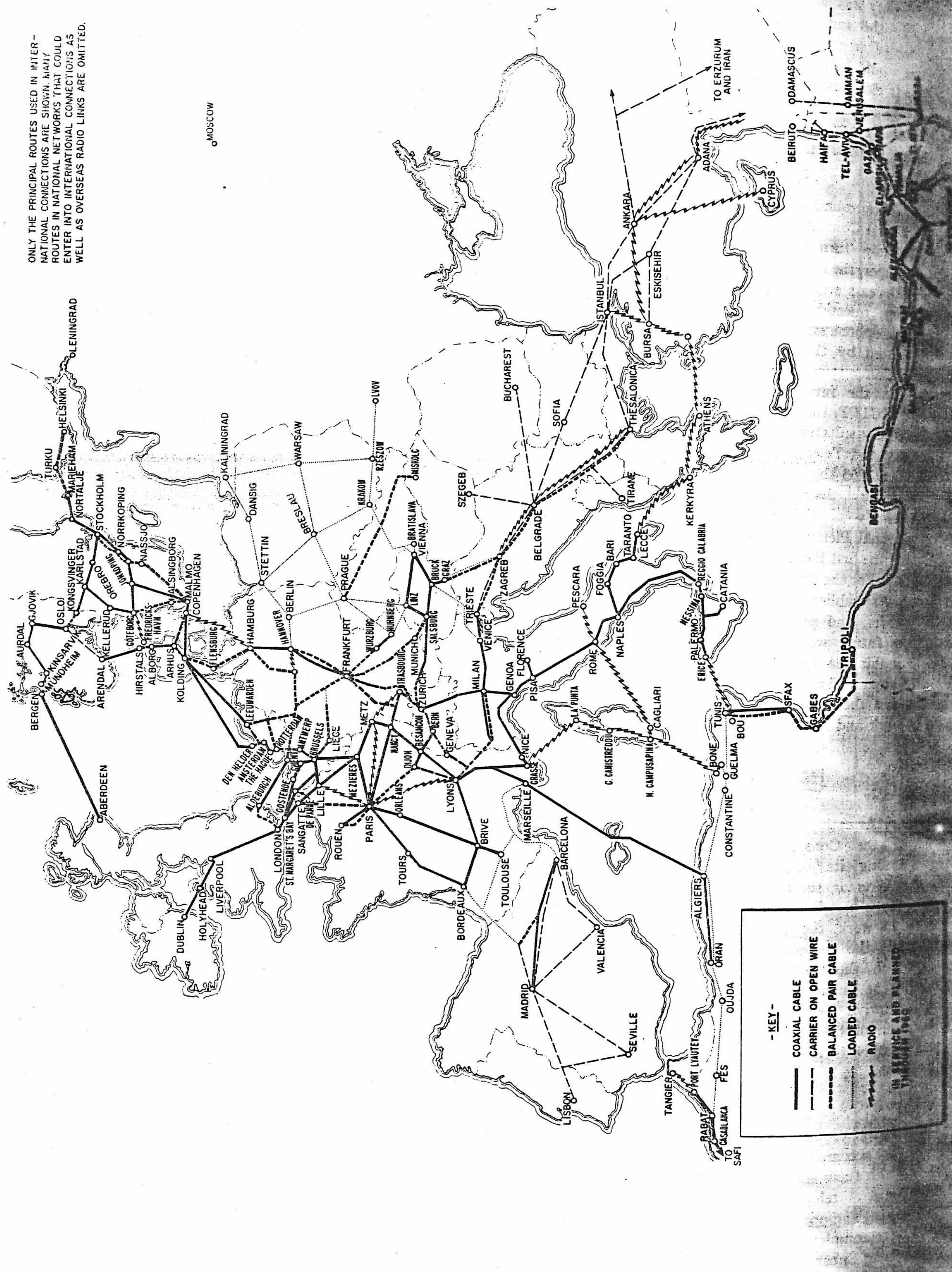
The post of Director of the new CCITT had to be filled by election at its First Plenary Assembly. The election for the post was strongly contested by five active candidates. Georges Valensi, who held the post in the CCIF since its inception in 1924, was prevented from being a candidate because of the compulsory retirement provisions for employees of the Union.

The light in which he is regarded was expressed at the final Plenary Assembly of the CCIF by the chief delegate of Italy, Mr. Gneme, and by the delegate of the United Kingdom, Mr. Barron. Extracts from their remarks are cited here because they serve to evaluate the importance of the Director's role as well as the highly deserved tribute they pay to Mr. Valensi. Mr. Gneme said in part:

> As regards Mr. Valensi's decisive contribution to the development of the international telephone network, I would recall that the Committee and its Laboratory, once set up, speedily produced fruitful results. In 1924, it was hardly possible to put a call through from one country to the next, . . . by 1938, all the European countries were linked by high-quality lines, ...
>
> After this initial period of creative activity, the problem arose of setting up new international lines with a higher transmission speed than the old coil-loaded cables. Thanks to the use of carrier systems, a great saving was effected in raw materials at the same time as quality was improved. The second modern long-distance line network has been set up in the light of the investigations undertaken by the CCIF, and the recommendations it has issued, during the last few years. The public has been made to benefit by technical inventions as soon as they got past the laboratory stage.

Mr. Barron said in part:

> Mr. Valensi has the exceptional ability of being able to carry out all his duties, both great and small, with the same abounding energy and impressive efficiency. The CCIF owes much of its success to this fact, because clearly the successful direction of such a body with its many complications and its wide technical span, must make heavy demands on its director, and the CCIF can count itself outstandingly fortunate in having had the services, over such a long and vital period, of a man who is at once an engineer, and administrator, and a politician (in the best sense). A man who can converse freely and fluently in a


ONLY THE PRINCIPAL ROUTES USED IN INTERNATIONAL CONNECTIONS ARE SHOWN. MANY ROUTES IN NATIONAL NETWORKS THAT COULD ENTER INTO INTERNATIONAL CONNECTIONS AS WELL AS OVERSEAS RADIO LINKS ARE OMITTED.
-KEY-
COAXIAL CABLE
CARRIER ON OPEN WIRE
BALANCED PAIR CABLE
LOADED CABLE
RADIO
IN SERVICE AND PLANNED THROUGH 1960
MOSCOW
LENINGRAD
HELSINKI
TURKU
MARIEHAM
NORTALJE
STOCKHOLM
NORRKOPING
NASSJO
HALSINGBORG
MALMO
COPENHAGEN
KARLSTAD
KONGSVINGER
OREBRO
GJOVIK
OSLO
AURDAL
KINSARVIK
TRONDHEIM
BERGEN
ARENDAL
KELLERUD
GOTEBORG
FREDRICKSHAVN
HIRSTALS
ALBORG
ARHUS
KOLDING
FLENSBURG
HAMBURG
HANNOVER
BERLIN
STETTIN
DANSIG
KALININGRAD
WARSAW
BRESLAU
KRAKOW
RZESZOW
LVOV
MISKOLC
PRAGUE
FRANKFURT
WURZBURG
NURNBERG
LINZ
SALSBURG
MUNICH
BRATISLAVA
VIENNA
BRUCK
GRAZ
ZAGREB
TRIESTE
VENICE
SZEGEB
BELGRADE
BUCHAREST
SOFIA
THESALONICA
ISTANBUL
BURSA
ESKISEHIR
ANKARA
ADANA
TO ERZURUM AND IRAN
CYPRUS
BEIRUTO
DAMASCUS
HAIFA
AMMAN
JERUSALEM
TEL-AVIV
GAZA
ATHENS
TIRANE
KERKYRA
LECCE
TARANTO
BARI
FOGGIA
PESCARA
NAPLES
ROME
FLORENCE
PISA
GENOA
MILAN
STRASBOURG
ZURICH
BERN
BESANCON
GENEVA
METZ
NANCY
DIJON
LYONS
NICE
GRASSE
MARSEILLE
LA PUNTA
C. CAMISTREDDU
N. CAMPUSAPINA
CAGLIARI
MESSINA
REGGIO CALABRIA
CATANIA
PALERMO
ERICE
TUNIS
BOU
BONE
GUELMA
CONSTANTINE
SFAX
GABES
TRIPOLI
BENGASI
ALGIERS
ORAN
OUJDA
FES
PORT LYAUTEY
TANGIER
RABAT
CASABLANCA
TO SAFI
LISBON
SEVILLE
MADRID
VALENCIA
BARCELONA
TOULOUSE
BORDEAUX
BRIVE
TOURS
ORLEANS
PARIS
ROUEN
MEZIERES
LILLE
LIEGE
BRUSSELS
ANTWERP
GHENT
OOSTENDE
ZOETERMEER
THE HAGUE
AMSTERDAM
DEN HELDER
LEEUWARDEN
ALDEBURGH
SANGATTE
DE PANNE
ST. MARGARET'S BAY
LONDON
LIVERPOOL
HOLYHEAD
DUBLIN
ABERDEEN

number of languages, and who couples with his efficiency those vital qualities in human relationships of humor, understanding, mystery, and humanity.

The position of Director is thus regarded properly as a key position in the field of international communications. The election finally went on the fourth ballot to Jean R. Rouvière of France. He resigned as Director General of Telecommunications for France to assume his new duties.

Presidents and Vice-Presidents of Study Groups and Substudy Groups

These, too, are positions of considerable influence. The appointments in the new CCITT were made from European administrations and the United Kingdom with one exception: a delegate of Pakistan was appointed Vice-President of the Study Group for the general plan for the development of the international network of Europe, the Mediterranean Basin, and South Asia.

This situation reflects the long history of emphasis primarily on the problems of the European network. In recent years, however, the deliberations of the Study Groups are becoming increasingly of world-wide significance. In the future, therefore, it can be expected that outstanding engineers from other areas of the world will find their way into the posts of President and Vice-President of the Study Groups.

It is the job of the Presidents to direct the efforts of the Study Groups to the solution of the problems presented to them. Considerable flexibility is needed in reconciling conflicting points of views, influenced perhaps at times by existing equipment situations, or established operating procedures. A knowledge of such conditions is evidently of great value to the Presidents. Some facility of expression in both French and English is also helpful for these positions, but is not essential.

METHODS AND PROCEDURES

Any member of the Consultative Committee can elect to participate in the work of any of the Study Groups and should, of course, do so where it is felt the country's interests will be served by such participation, or where it can make significant contributions.

The work of the Study Groups consists of consideration of questions which are of active interest and significance to the current developments of the members themselves. Authority to consider these questions is given principally by the Plenary Assembly.

A typical program is that studied by CCIF in the period 1954–56. It consisted of the following:

Subject	Number of Questions
Transmission lines and systems	61
Transmission performance of telephone sets and local networks, etc.	18
Switching and signaling	13
Electrical protection and corrosion	43
Traffic operations and rates	25
Integration of wire and radio systems	19
Maintenance of lines and systems	16
Definitions, vocabulary, symbols	7

Obviously, complete agreement on a program as comprehensive as this is not possible. It frequently happens that questions are continued from one period to the next, with the same or new wording depending on current developments in the particular field.

Normally the questions for study are forwarded to the members of the Study Groups soon after the Plenary Assembly which authorized them. Many questions bracket the areas of interest of two or more Study Groups and are jointly studied. Any responses or contributions which the members can make are due approximately a year in advance of the next Plenary Assembly. There is thus a period of about 2 years in which to study the questions and propose solutions. It is to be expected that because of the variations in interest of the communication problems under study, and of limitations in manpower, all members will not respond to all questions; in fact, no one member ever has.

During this same period, a Working Party assigned specific tasks will have had exchanges of correspondence, and probably one or two meetings to prepare a report on its activities.

Some months, or even as much as a year, preceding the Plenary Assembly, the Study Groups may meet to consider all the responses received, together with the reports of any Working Parties they had created. Out of these meetings come draft recommendations, and decisions as to whether questions have been completed or should be continued. Normally as many as half the questions are of a fundamental nature or deal with a rapidly developing aspect of telephony, and may be continued in study over a long period of years. For such, interim recommendations, which have been based on the current state of the art, are drafted.

Additional meetings of Study Groups, primarily to review and edit the draft recommendations, are held immediately prior to the Plenary Assembly. The final stamp of approval of recommendations is made by the Plenary Assembly, which also makes provision for their publication.

The approved recommendations aspire to be a common acceptable basis for establishing international circuits or for engineering internal networks which are interconnected with such circuits. These recommendations are not mandatory and do not carry the force of regulations. They do stand as a guide and objective for all to follow as the state of the art and economics permit. In fact, the soundness of these recommendations and their adaptability to various situations tend to make it unnecessary to establish rigid regulations in these matters.

For example, the CCITT 1956 Plenary Assembly inherited from CCIF, and continued in study, a question relating to the design practices and objectives used by its members for their national trunk and exchange networks. The presence of this question on the agenda reflects recognition of the fact that as continuing improvements are made in international circuits, the limiting factor on the over-all grade of service becomes in an increasing degree the performance of the national facilities involved in completing the call. Generally, it might be expected that national networks providing a modern grade of service based on forward-looking engineering, are automatically adequate for completion of international calls. Unfortunately, for a variety of reasons, and some very good ones at that, this is not universally true. The responses to this question will be of great value in pointing up the need for common objectives on a world-wide basis.

ACHIEVEMENTS

It would be impractical to list completely the accomplishments of the International Telephone Consultative Committee during its lifetime.* As a matter of fact, the recommendations resulting from its work, useful in current operations, fill six volumes totalling some 1,500 pages. These are supplemented by voluminous annexes which contain documentation in support of the recommendations. It will be useful, however, to outline the broad areas of activity to indicate the wide scope of its activities.

Since the Committee's primary concern is good international telephone service (fast, easy to use, dependable, and at reasonable cost), one of its early accomplishments was the establishment of

---

* The first Plenary Assembly of the CCITT adopted a recommendation by the CCIF to organize a task force to prepare, in French and English, a complete history of the CCIF as a publication of the Union.

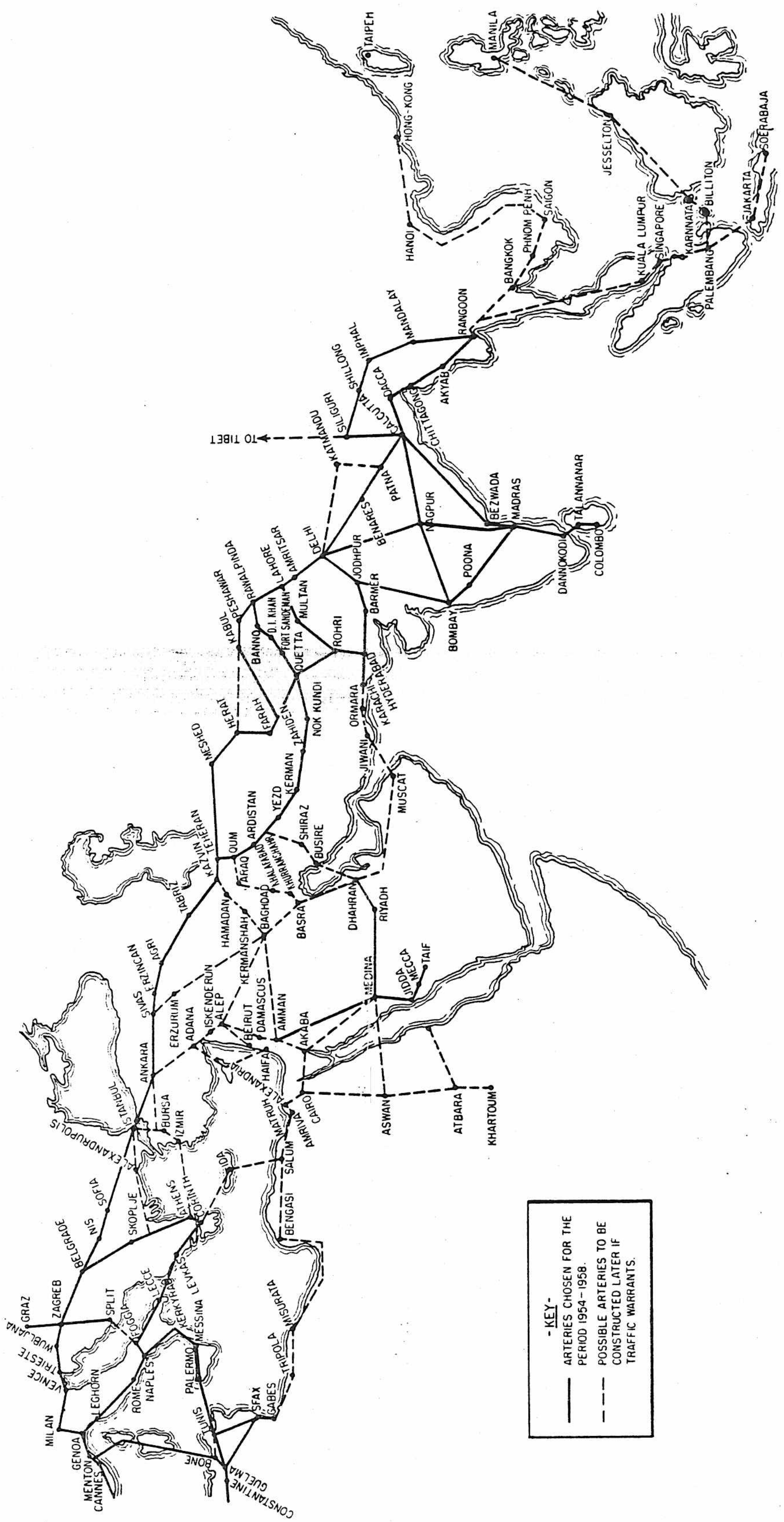


Fig. 4. Network of high-speed telephone lines in South Asia and the Middle East and interconnection with the Mediterranean Basin

transmission design objectives for international circuits. This led logically to agreements on the design parameters for transmission systems of all types, carrier and radio. This is a matter of paramount importance, when it is realized that an international call in Europe, going no farther than one from Boston, Mass., to Washington, D. C., or Quebec to Ottawa, in Canada, may be handled by carrier systems where the ownership of the terminals will be divided between two nations, the terminals themselves may have been actually supplied by two different manufacturers, and the system may have been routed over the lines of still a third country.

Concurrently with the establishment of design objectives, agreement had to be reached on methods of measurement to assure that the objectives were being met. This, in itself, has covered virtually every aspect of electrical communication measurements.

Dependability of service rests not only on proper design, but is equally dependent on the skill and thoroughness with which the facilities are maintained and adjusted. Activity in this field has produced agreement on maintenance methods, routines for establishing, and periodic testing of circuits, etc.

As already discussed, no matter how well designed and maintained the international network may be, the grade of service will be determined to a very important degree by the characteristics of the telephone instruments at the subscriber's premises, and of the connecting facilities of the national networks. The telephone sets of the world, supplied by a great number of manufacturers, have probably the widest divergence in their essential transmission characteristics. A great deal of effort has been expended in trying to arrive at a common basis of comparison which would permit a generally accepted measure of the quality of performance of the individual sets. It cannot be said at this time that this matter has been completely resolved.

Many of the nations of Europe have made extensive progress in operator and direct distance dialing within their own borders. This inevitably has led to studies for the extension of dialing, both by operators and by the subscribers direct on international calls. This is another problem of great complexity, because it means the integration of dialing and signaling systems developed for the national networks, into the international network. As would be expected of any progressive and free-thinking organization, many plans were offered. After some years of study two plans seemed to offer the best possibilities. Both arrange for supervision and dialing information to be transmitted in the voice band: one uses two frequencies to accomplish this, the other uses one. These were given extensive service trials in two areas of the European continent and some final recommendations regarding both have now been established.

In order to demonstrate what has been accomplished in international dialing, experimental arrangements were set up so that delegates at the meetings in Geneva in December 1956 could dial directly from telephones at the conference building into the networks of Brussels, Belgium; Germany; London, England; Milan, Italy; the Netherlands; Paris, France; and Stockholm, Sweden.

The accomplishments so far discussed are purely technical. Building on this work, the Committee has also produced a fundamental switching plan for international service. Initially this was confined to the continent of Europe and the United Kingdom. As the second step, the plan was extended to include the countries bordering on the Mediterranean Sea, and the third step was to make tentative plans for extensions to the Middle East and South Asia. Fig. 3 shows the network of high-velocity facilities (in service and proposed) in Europe and the Mediterranean Basin, and Fig. 4 the projected main arteries to the Middle East and South Asia.

The operation of such networks, of course, involves agreement on operating procedures, priority of calls, methods of billing, and apportionment of revenues, this last a difficult problem in connection with alternate routing through third countries.

The Consultative Committee has also concerned itself with requirements for program circuits used in connection with radiobroadcasting; the special considerations when voice-frequency telegraph circuits are operated on telephone-type channels; the interconnection of mobile radio systems with the wire network; and the very special types of problems associated with the long intercontinental circuits, which now span the seven seas.

The Committee has given a great deal of attention to problems of external interference and considerations of safety. This has resulted in setting specific objectives together with recommended practices in dealing with problems of interference and hazards to communication systems. The Committee's recommendations, based upon the pool of general experience, have been constructive.

Impressive as the accomplishments of this Consultative Committee are, it still has a formidable program ahead of it. To mention a few of its problems there are a rating system for the transmission performance of telephone sets; the transmission requirements for facilities used for television transmission; the contemplated extension of the standard European 6-megacycle coaxial system to 12 megacycles; the integration of radio systems, and particularly microwave, into the telephone network; and a reconsideration of the transmission design and maintenance of international circuits in the European network in view of the widespread availability of high-velocity facilities. (It has appeared to forward-looking European engineers a bit incongruous that a New York–Copenhagen trunk via the new transatlantic cable, about 5,000 statute miles, is operated at 6 decibels, whereas a 290-mile London–Paris call at present is operated at 7 decibels.)

PUBLICATIONS

It was mentioned earlier that the recommendations of the Telephone Consultative Committee have been published in a series of six books supplemented by other volumes containing related documentation furnished by the member organizations. In addition, there are special volumes covering the general switching plan, semi- and full automatic operation of the European network, directives on corrosion and protection, operators' instructions, maintenance phrases, definitions, and vocabulary. These volumes are more than bare recommendations. They include extensive background material, affording a better appreciation of the factors leading to the recommendations. This has proved to be of particular value to those countries whose communication systems are in the early stages of development.

Technical Assistance to Underdeveloped Countries

The Consultative Committees have made significant contributions to the United Nations expanded program for technical assistance to underdeveloped areas. The publications of the Telephone Consultative Committee have been an important part of this activity. Going beyond this, however, the Committee, through its acquaintanceship with engineers all over the world, and its knowledge of their particular qualifications, has been able to suggest candidates to the United Nations for specific missions to countries desiring aid. It has also been in a position, through its work, to make comments on the soundness of plans proposed by some of these countries, and has suggested modifications which might result in a more effective use of each country's resources. In another field, it has been able to give advice in connection with locating students receiving fellowship grants in specific areas. The Plenary Assembly in Geneva in 1956 reaffirmed this program of aid, and in addition concurred in the creation of a joint CCITT-CCIR (Radio) Working Party to examine further what additional contribution could be made by the Consultative Committees to the Technical Assistance Program.

In the discussions directed towards the Consultative Committees' efforts in the technical assistance program there seemed to be a strong feeling of concern on the part of the underdeveloped countries with programs for expanding their telecommunications, lest they be misguided into the purchase of systems which would not be compatible with other internal or external systems. The desire of such countries to obtain access to universal communications by facilities in keeping with the recommendations of the Consultative Committee was evident. The Plenary Assembly, by formal declaration, urged the underdeveloped countries to avail themselves of the full advantages of active membership of the Consultative Committee and its Study Groups.

Some Considerations of Significance

To the engineer it is evident that one of the principal achievements of the Consultative Committee lies in the awareness of a common objective which it has succeeded in creating against a background of diverse national, political, and traditional points of view.

Regarding communications in its worldwide aspect, it may naturally be asked why solutions which have been proved in application in North America do not always find ready and complete acceptance in Europe and vice versa. This, of course, points up the fact that sound engineering is not a technical matter alone, but must inevitably weigh also questions of investment, operating costs, climatic conditions, manufacturing, availability of manpower, money situations, political factors, and others. There is the basic need to make available universally the fundamental concepts and techniques of improved communications which may be applied by any nation in the light of its own national circumstances. The Consultative Committee provides the medium and the knowledge for such a constructive approach.

It is of interest, and probably of value, to remark that communication developments, such as the concept of carrier over both physical and radio channels, have inevitably resulted in a changing point of view, from one of restricted use of international media, both by regulation and by cost of service, to one of abundance producing readier access and lower costs. In this regard it may be observed that, from the authors' point of view, the Telephone Regulations for the European region (Paris revision 1949) annexed to the International Telecommunication Convention, are in many respects already outmoded in such features as classification of calls and priorities of acceptance of business offered to the international network. This is particularly true in view of present-day concepts of direct distance dialing.

This brings out an apparent difference in attitude on such matters as regulations which could affect the day-to-day operations of a communication network. On the North American continent such regulations, which can be changed only by action at the diplomatic level, are considered undesirable by the engineer because of the restrictions they may well place on taking prompt advantage of advances in the art resulting from improved understanding and research. On the European continent, however, it would appear that regulation between nations is accepted as a means to ensure adherence to standards in design or operation which have been debated to the point of common acceptance. In the operation of the communication networks of North America, such a position appears inflexible and forbidding. Further, on this continent, the operating agencies themselves have the responsibility for determining detailed practices which they will follow within the scope of broad governmental regulation.

These considerations, together with the fact that the Regulations are subscribed to by the countries concerned at the diplomatic level, and call for their imposition by their governments, makes adoption of them in North America all the more unacceptable. Consequently, many countries, including the United States and Canada, in the Final Protocol to the 1952 Convention, took official formal exception to the imposition of Telephone Regulations as an obligatory matter.

Significance of the Consultative Committee's Work to North America

The relations between the United States and Canada in the field of telephony are such that there has developed a mutual understanding, and a working together towards common objectives in telephone service quality. Major telephone operating organizations of Canada and the United States interchange information and experience freely, and improvements are used as soon as practicable after they appear. In light of this situation and of the relatively small part intercontinental traffic has so far played in the over-all operations, together with the highly special character of facilities to handle it, there has not been an urgency for establishing a close working liaison with the methods and designs of European systems. As a result, the Recognized Private Operating Agencies of the United States and Canada have not considered it appropriate to take a position on decisions relating strictly to the European region. They have, however, taken a very active part in the deliberations on truly world-wide questions.

This is not to imply a passive role. A member since 1929, the American Telephone and Telegraph Company, by virtue of its scope and diversity of operations, and its technical advances, has been in a position to contribute importantly to all phases of CCIF work. The Telephone Association of Canada, while a comparative newcomer, is already making its influence felt. On the other hand, both organizations are deriving benefit from their activity in the international body, not the least of which is the mutual respect of engineers on both sides of the Atlantic.

But new conditions are changing the picture. Although intercontinental telephone service has been available for 30 years, the upsurge in traffic which followed the placing in service of the transatlantic cable, has made it evident that a new era in intercontinental telephony has been born. It is increasingly necessary that the objectives in transmission design, and in operation of systems of telephony, be made consistent to the degree that the advantages offered by these intercontinental circuits are fully utilized in the interest of better communications. This can be done only by world-wide recognition of the importance of good objectives in the design of national networks which it will be practicable to interconnect. The North American continent is thus inevitably being drawn into deeper participation in broader areas of the Consultative Committee's work to the end of gaining universal recognition of objectives and the necessity of constant planning to meet them both in Europe and on this continent.

In this paper, attention has been directed to the field of international telephony. There are equally stimulating and impressive stories to be written of the work of the International Consultative Committees for Telegraphy and for Radio Communication. It may not be amiss to point out that all of these International Consultative Committees in making their outstanding contributions to human welfare, have been directed and influenced in all their decisions by the thinking of engineers. The instinctive desire of this profession to obtain the best practical solution in a sea of difficulties stands out here, independent of influences that may be prejudiced by nationally restricted points of view. In this there may indeed be a lesson for meditation.

References

1. International Telecommunication Convention, Buenos Aires, 1952. General Secretariat, International Telecommunication Union, Geneva, Switzerland.

2. The International Telecommunication Union (book), G. A. Codding, Jr. E. J. Brill, Leiden, Netherlands, 1952.

650 DATA PROCESSING SYSTEM BULLETIN

GENERAL INFORMATION, CONSOLE OPERATION, SPECIAL DEVICES

This bulletin is one of a series of three bulletins on the 650 Card System. The other bulletin form numbers are: G24-5001 and G24-5002. These three bulletins obsolete the 650 Manual of Operation, Form 22-6060. In addition, the Special Devices section of this bulletin contains information that obsoletes the 654 Manual of Operation, Form 22-6367.

General Information

The IBM 650 has all the advantages of stored programming high component reliability, self-checking automatic operation, compact design, and ease of operation. Because of its great flexibility, the IBM 650 serves the needs of accounting, engineering, and scientific fields efficiently.

Functional Configuration

Control of the 650 system is exercised through the medium of a stored program. It has, as do most data processing systems, an integration of four basic functional blocks (Figure 1). We must remember that although the hardware of a 650 system can vary, the basic philosophy of these four blocks does not change. For example, the 533 Card Read Punch, the 537 Card Read Punch, or the 407 Accounting Machine can be used as a card input machine for this system.

Input-Output

The input block is used to enter transaction data, instructions, etc., into the storage block of the system. In the 650 system, the input usually takes the form of units capable of reading and translating IBM cards into 650 language.

The output block is used to take the results of processing out of the system, and convert from 650 language to output language. The output devices usually take the form of units capable of punching IBM cards, or printing a report on paper.

Input-output units for the 650 can be combined into various physical configurations to meet the varying needs of diversified users. Their operation is supervised by the control block.

© 1958 by International Business Machines Corporation

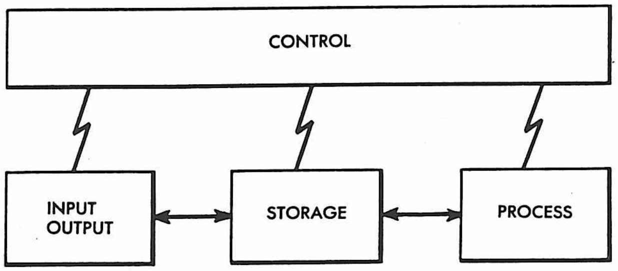


Figure 1. Basic Data Processing System

The use of magnetic tape as both input and output media is discussed in a later 650 Bulletin, Form G24-5003.

Storage

The storage block of the system is used for storing transaction data, instructions, tables, intermediate results, final results, historical data, summary files, master records, and any other information that can profitably be stored within the machine. The physical form that the storage takes is determined by the amount and type of data to be stored, and the frequency of its use. The 650 system uses four types of magnetic storage:

1. drum
2. core
3. tape
4. disk

Each of these media is characterized by the high speed with which records can be read from and written into it.

The movement of data into or out of storage is supervised by the control block.

Special Devices

Alphabetic and Special Character Devices

These devices, available for use with the 533, 537, and 407 are used to convert the punching (numeric, alphabetic, special character) in any *one* column of the input card, into *two* numeric digits within the 650 System. Similarly, the devices convert the *two* numeric digits within the 650 into *one* character for output. These conversions take place as the information is being transferred to and from the input-output units and the synchronizers. The first six-storage entry and exit words can be used, giving a total capacity of 30 characters input and output.

The basic device is the alphabetic device. The Special-Character Device is an addition to the alphabetic device and can be installed in either one of two options, Group I or Group II. Figure 24 shows all the alphabetic, numerical, and special-character codes as they appear in the card and within the 650, after being converted by the devices. Also shown is the particular device that handles each individual character.

Character		Card Code	650 Code	Handled by *	Character	Card Code	650 Code	Handled by
Blank			0 0	A	M	11-4	7 4	A
Period	.	12-3-8	1 8	C	N	11-5	7 5	A
Lozenge	⌑	12-4-8	1 9	C	O	11-6	7 6	A
Ampersand	&	12	2 0	B, C	P	11-7	7 7	A
Dollar Sign	$	11-3-8	2 8	C	Q	11-8	7 8	A
Asterisk	*	11-4-8	2 9	C	R	11-9	7 9	A
Dash	-	11	3 0	B, C	S	0-2	8 2	A
Diagonal	/	0-1	3 1	C	T	0-3	8 3	A
Comma	,	0-3-8	3 8	C	U	0-4	8 4	A
Per Cent	%	0-4-8	3 9	C	V	0-5	8 5	A
Pound	#	3-8	4 8	C	W	0-6	8 6	A
At	@	4-8	4 9	C	X	0-7	8 7	A
A		12-1	6 1	A	Y	0-8	8 8	A
B		12-2	6 2	A	Z	0-9	8 9	A
C		12-3	6 3	A	0	0	9 0	A
D		12-4	6 4	A	1	1	9 1	A
E		12-5	6 5	A	2	2	9 2	A
F		12-6	6 6	A	3	3	9 3	A
G		12-7	6 7	A	4	4	9 4	A
H		12-8	6 8	A	5	5	9 5	A
I		12-9	6 9	A	6	6	9 6	A
J		11-1	7 1	A	7	7	9 7	A
K		11-2	7 2	A	8	8	9 8	A
L		11-3	7 3	A	9	9	9 9	A

* A Alphabetic Device
B Special Character Device, Group I
C Special Character Device, Group II

Figure 24. Alphabet and Special Character Codes

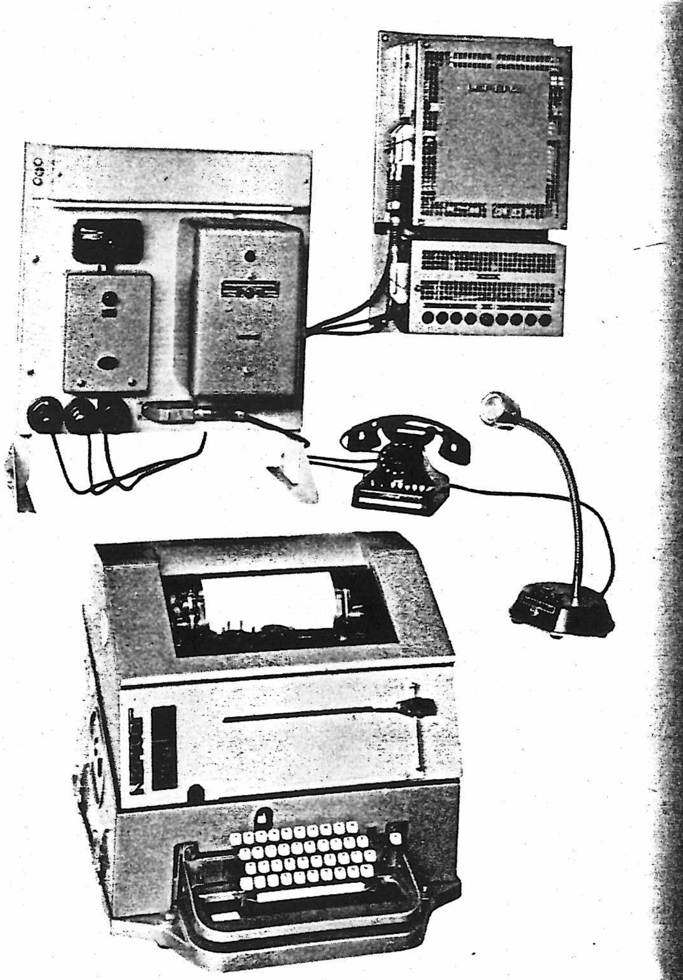


Figure 7—Test setup with the *SEF-7* very-high-frequency radio equipment. The *UT-57/1* strip is mounted on the transfer-equipment frame just back of the teleprinter.

receiving branch is still sufficient for practically undisturbed teleprinter operation. In the *SEF-7* receiver, this corresponds to a receiving field strength of about 1 microvolt per meter. White noise was used as interference in these measurements. The noise suppressor built into the radio equipment must not be switched off i frequency telegraphy operation because of the transmitting carrier will incre sensitivity of the radio receiver and the ference noise present will be powerful en start the teleprinter.

Development of Creed Telegraph Apparatus

By BRUCE BROOKE-WAVELL

Creed & Company, Limited; Croydon, England

MOLIÈRE'S character, M. Jourdain, awoke one day to the realization that he had been speaking prose all his life without knowing it. Similarly, telegraph engineers have recently discovered, thanks to Claude Shannon and others, that they have been processing digital information for the last hundred years without being aware of that fact. Fortunately for telegraph manufacturers, many other people have discovered this fact too, even if in some cases they have required a little prompting.

The result has been, during the past five years, that a wide range of telegraph apparatus that was originally developed for purely conventional telegraph applications has been used for quite different purposes. The punched-tape technique, for example, that was originally introduced to save line time is now employed for providing input and output facilities for digital computers, for data recording and processing, and for the automatic control of machine tools.

Back in 1948, however, at the beginning of the ten-year period being reviewed, telegraph engineers were too fully occupied with the pressing post-war requirements of conventional telegraphy to give much attention to other matters. This was certainly true at Creed where, during the war, production was for strategic reasons concentrated on a small range of telegraph machines and in particular on the model-7 page teleprinter, which accounted for over half of the total number of machines turned out. There was, therefore, the urgent problem of pushing ahead with a variety of new developments to meet the needs of both British and overseas telegraph administrations.

1. *Early Post-War Development*

The first such development was for the British Post Office which started to reorganize its public telegraph service. To replace the prewar model-*3* tape teleprinter, which since its introduction in 1929 had been in general use for the transmission and reception of telegrams, the model-*47* tape teleprinter was produced. This machine was similar in principle of operation to the model *7* page teleprinter but embodied improvements resulting from experience with that model and from Post Office experience with the earlier tape machine. Perhaps the most important difference between the models *47* and *7* teleprinters, apart from the obvious one that the page unit on the latter machine had been replaced by a tape unit on the former, was that the model *47* had a 4-row, typewriter-pattern-layout, saw-tooth-comb bar keyboard in place of the earlier 3-row motorized keyboard.

There next followed a series of developments concerned with the provision of automatic tape transmission facilities for the full utilization of line time. This was to meet the increasing interest being shown in simple tape preparation and automatic transmission sets for use both in individual installations and in the more-ambitious manual-transfer push-button semi-automatic tape relay systems.

Equipment for automatic tape transmission sets had been in production since before the war, including a keyboard perforator, a nonprinting reperforator, and an automatic tape transmitter, but a further range of machines was now introduced mainly for use in tape relay systems. The model-*85* printing reperforator was developed for recording messages on printed chadless tape, that is, perforated tape with the chads remaining attached and with the printing superimposed on them. The printing was provided to eliminate the need for operators to read the 5-unit code and the chadless method of perforating to retain the use of standard-width tape. A variant of this machine—the model-*86* printing reperforator—recorded messages on fully perforated wide tape with the printing underneath the perforations.

An essential requirement in tape relay stations is the use of ganged automatic tape transmitters. To meet this requirement, models *71*, *72*, and *74* multiple-tape transmitters were produced. The standard single-head transmitter, model *6S*, was

vol 73

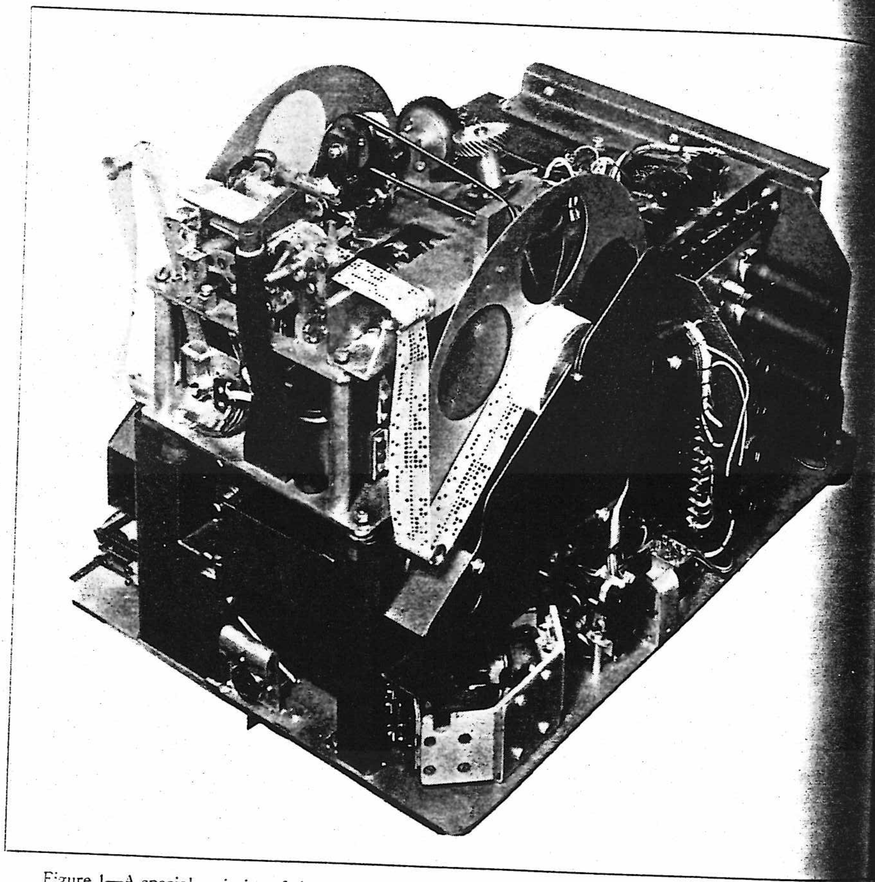


Figure 1—A special variation of the model-*25* reperforator. It provides a punched-tape record of the ro operations of equipment such as cash registers and accounting machines for computer input.

redesigned, a transmitting mechanism of the striker pattern being fitted to it to ensure high-quality signals.

Meanwhile, the increasing use of teleprinters by business concerns renting circuits from the British Post Office, as well as the changing needs of telegraph administrations, made it necessary to add to the model-*7* page teleprinter, which was still in great demand, a variety of new facilities.

This machine had been introduced in 1931 as a simple, sturdy teleprinter in which the design emphasis had been on simplicity of manufacture and maintenance rather than on a large of facilities. These characteristics were, u edly, of great value to the armed services British Defence Teleprinter Network in the bulk of the war-time production wa The changed circumstances after the wa ever, created new needs.

The machine was designed origin double-current (polar) operation: it w modified to make it equally suitable fo current (neutral) operation. A new ca was fitted to it having an orientation that is, a means for centralizing the ma

for measuring the receiver tolerance in the absence of a separate margin-testing set. Later, a further alternative cam unit was made available to provide for immediate printing and to increase the receiver tolerance to over 86 per cent. A reperforating attachment was fitted that could be used to prepare perforated tape with a local record or provide a perforated record of incoming messages as required. Two-colour printing, a period-of-operation counter, improved visibility of the printing point, better sound-proofing arrangements, and many other changes were introduced, transforming the teleprinter into what superficially appeared to be quite a different machine. As the original simple teleprinter continued to sell to customers who did not need these new facilities, the modified machine was distinguished as being the new model *54*.

2. *New Applications*

About five years ago, as already mentioned, a series of entirely new markets with requirements quite unknown to the telegraph art began to appear. Digital-computer manufacturers turned to punched tape as a way of solving their input and output problems. The development of the techniques of data recording and processing, as well as of automation, created a demand for further kinds of punched-tape equipment.

To meet the need of the computer manufacturers, a comprehensive range of *tape-editing* equipment in the form of selfcontained comparator, verifier, and reproducer sets were developed. These consisted of standard teleprinter equipments to which new facilities had been added, together with specially designed relay units and control panels. A series of interpreter sets was also produced to provide computer print-out facilities.

It was early realised that while normal telegraph speeds would be more-or-less adequate for tape-editing equipment, much higher speeds were required for the input and output devices. The computer manufacturers found a satisfactory method of reading input tapes by using photoelectric means for registering the holes. Creed did not, therefore, develop a high-speed tape reader.

The output problem, however, was a more-difficult one that was approached initially by introducing the model-*7P/5W* reperforator. This was derived by modifying a keyboard perforator to reperforate from a 5-wire input. It operated at 15 characters per second, thereby permitting recording at slightly over twice the speed formerly possible with standard teleprinter equipment.

The next step was the introduction of a tape punch that was specifically designed for output recording. This model-*25* reperforator records data in 5-, 6-, or 7-track tapes—either in single tapes or in two tapes at a time—at a speed of *33* characters per second, which is 5 times the normal teleprinter speed. The model-*25* reperforator is at present the standard output punch for the majority of British electronic digital computers. Over 1000 of them have been produced to date for this and other applications, which include the automatic logging of telephone calls on punched tape and the provision of a punched-tape record of the automatic routine operations of a range of modern business equipment such as cash registers and accounting machines. Figure 1 shows the mechanism of one of these models.

The speed of the model-*25* reperforator is still not high enough, however, to make it a completely adequate computer output recorder. Two further machines have, therefore, been developed for this purpose. The first, the model-*3000* reperforator, is the world's fastest output punch, operating at a speed of 300 characters per second. It may be seen in Figure 2. The other is a hydraulically operated character-by-character printer with a speed of 100 characters per second. This operates from a 5-wire input, the characters being built up on the mosaic principle with a 5 by 5 grid. As it has 3 times the speed of the model-*25* reperforator, it is advantageous to use it as a direct-output printer. Alternatively, it may be used in conjunction with the model-*3000* reperforator if a higher output speed is required. The speeds obtainable with these machines are adequate for most purposes. Since they are much-less expensive than the higher-speed line printers on the market, they will undoubtedly satisfy an important need in the computer field. Figure 3 is an example of the use of teleprinter equipment adapted to computer requirements.

A range of machines is also under development in the data processing and automation fields. These are, in most cases but not all, modified versions of standard teleprinter equipment and include a machine for recording 5-unit combinations on the edges of cards and tickets, a tape transmitter for process control by punched tape, which has been modified to feed forwards or backwards under the control of external signals,

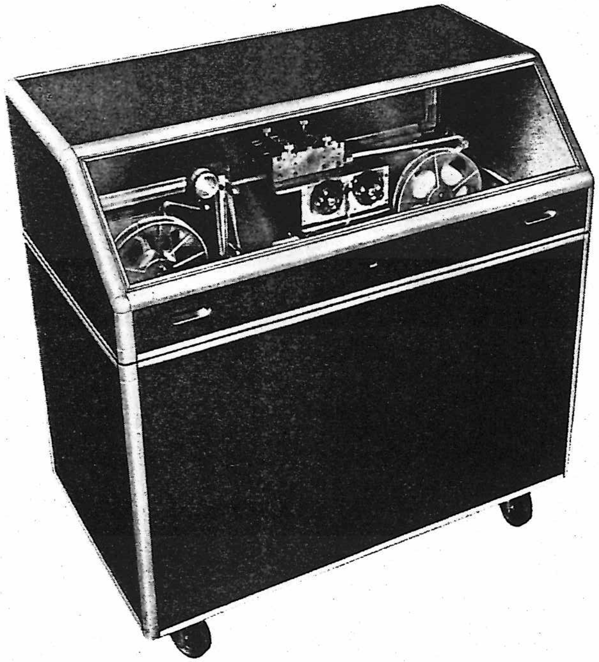


Figure 2—Model-*3000* tape punch. It was designed for use as the output equipment for electronic computers. It can punch 5-, 6-, 7-, or 8-track tape at the high speed of 300 characters per second or 3000 words per minute.

and a teleprinter that operates directly from a 5-wire input.

All these are individual instruments that have been produced for use in conjunction with other manufacturers' equipment. Creed is also investigating the problem of providing complete integrated data-processing systems using punched tape throughout, for use where the total quantity of information to be processed is not sufficient to justify the employment of electronic equipment.

The next step will almost certainly be the extension of both the computer and data-processing fields to include telegraph communication facilities. When this occurs, the dem higher speeds of operation, codes with a information-carrying capacity, and new ards of transmission accuracy will ra affect present telegraph practice.

3. *Fresh Start in Te printer Design*

The history of the *7* and *54* teleprinters a rapid growth of no graphic applications o graph apparatus both an important part in mining the design o new model-Seventy-fi printer.

Some four years a was realised that the *54* teleprinter, whil adequate for normal munication needs, cou be modified to meet th requirements that we ing in the communicati data processing fields w undue complication a crease of weight.

To take the com tion field first, it was ing evident that w accelerating expansio telex and private-w vices, the teleprinter coming an indispensa of office furniture on th basis as, although complementary to, th phone. There was reason to believe th large telegraph organisations, both pub private, would tend in the future to pro interconnection facilities such as switch channel equipment, but leave the opera servicing responsibilities to the user.

From this the conclusion was drawn th printers would have to meet, in the near the following requirements:–

A. *Reduced Maintenance.* The dispersal graph equipment in business offices ins their previous concentration in telegraph would put a premium on low maintenanc

B. *Dual-Speed Operation.* For economic reasons, there would be a strong demand for automatic tape transmission sets. An improvement on present practice could be made if a dual-speed teleprinter with a manual speed-change control were used that could prepare tape "off line" at a high speed and provide message transmission facilities "on line" at the normal telegraph speed.

C. *Modern Appearance and Small Size.* If teleprinters were to become standard office furniture, their appearance and size would play a more-important role than in the past.

These requirements were seen to hold also for the data-processing field, but there were additional requirements. It was apparent that an increasing demand would exist for communication channels between business offices and centrally placed computers serving them. Many of these business offices would not want full-time channels but would prefer channels that could be used partly for transmitting data and partly for normal communication traffic. There would, therefore, be an advantage in using dual-purpose terminal equipment that would be suitable for the transmission and reception of messages and also for the local processing of data. As these two kinds of use ideally require sequential and simultaneous (5-wire) modes of signalling respectively, a satisfactory dual-purpose machine would have to be readily convertible from one mode of signalling to the other.

All these requirements have been met in the design of the model-Seventy-five teleprinter, which needs less-frequent maintenance than previous Creed teleprinters, operates at both 66 and

Figure 3—Application of teleprinter equipment to record output data from an electronic digital computer in punched-tape and printed-page form.